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TEXAS INSTRUMENTS
INCORPORATED

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CUMBERLAND PLATEAU
SEISMOLOGICAL OBSERVATORY

Quarterly Report No. 4
1 May 1966 through 31 July 1966

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SECTION I

INTRODUCTION

This report reviews the operations and research work conducted by Texas Instruments Incorporated during May, June and July 1966 on the Cumberland Plateau Observatory (CPO) contract. Efforts during this period have been directed toward routine observatory operations, Dallas- and station-conducted research tasks and design and construction of a detection and identification digital processor.

Operation of CPO during the reported period has continued on a routine basis. Magnetic tape and film data have been high quality. The overall observatory maintenance configuration is good, and minimum station down-time has been reported as a result of a sound, continuing preventive maintenance program.

Research activities during the quarter have concentrated on evaluation of the MCF processor, ambient noise studies and detection processor simulation. Data are presented which demonstrate a significant increase in station detection capability as a result of on-line MCF processing.

As of 31 July, construction of the auxiliary processor was 42 percent complete, and the program was on schedule.



SECTION II

OBSERVATORY OPERATIONS AND RESEARCH

A. GENERAL

This section presents details of special interest concerning the station operations and research which have been accomplished during the past quarter. A review of the past year's station down-time data has been included along with reliability information on the MCF processor.

B. STATION ANALYSIS

Station analysis has proceeded on schedule. Data recordings have been very good with a few instrument failures being the only major problems incurred. (Section II D3). Lightning storms have also limited data recordings on several occasions by causing numerous cable breaks as shown in Table 1. The number of events recorded during the quarter are as follows:

<u>Month</u>	<u>Teleseisms</u>	<u>Regionals</u>	<u>Near Regionals</u>	<u>Locals</u>
May	644	5	2	1
June	699	3	-	-
July	555	42	-	-

This is a total of 1951 events which is by far the largest number of events recorded during any of the past four quarters. Section III presents a discussion of the number of events reported during July with and without the use of data from the DMCF.

C. STATION RESEARCH

Station research during the reported quarter has been directed primarily toward evaluation of the MCF processor. This has included a study of the increase in detection capability afforded CPO by the MCF, and a study of the MCF hardware reliability. This latter task is covered in more detail below, while results of the former are presented in Section III.

D. STATION INSTRUMENTATION

1. General

The station engineering section has continued routine preventative



Table 1
CPO DOWN-TIMES

Unit Affected	Date	Cause	Approximate Elapsed Time (hr)	Tape	Data Loss Film	None	Serious Data Loss
Tape 1	5/9/65	Bad connection in relay	2.0	X			*
WWV	5/18/65	Open primary in output transformer	8.0			X	
IBZ	5/19/65	Sticking data coil	36.0	X	X		
Z-1, Z-2, Z-3, Z-4, Z-5, Z-7, Z-9, Z-15, Z-16, Z-17, Z-18, NSP, ESP, ZIB, NIB, EIB, ELP, Microbarograph, Anemometer	5/25/65	Electrical storm	1.25	X	X		*
Tape 1	6/11/65	Blown fuse	0.16	X			*
Timing System	6/12/65	Aging components	15.0			X	
ZIB, EBB	6/19/65	Blown fuse and sticking coil	1.0	X	X		
Develocorder	6/28/65	Faulty pump in secondary develocorder (no loss of primary data)	9.0		X		
Z-4	7/3/65	Electrical storm	0.33		X		
Z-1	7/5/65	Electrical storm	0.33		X		
Power Control Unit	7/7/65	Replace burned out relays	0.5	X	X		*
Z-2, Z-6	7/7/65	Electrical storm	2.0	X	X		
IBZ	7/13/65	PTA galvo and sticking coil in seismometer replaced	6.0	X	X		
IBZ	7/14/65	Broken wire in seismometer	1.0	X	X		
Tape 1	7/15/65	Replace record head	0.5	X			*
LPZ	7/14/65	Intermittantly inoperative	8.0	X	X		
LPZ	7/19/65	PTA maintenance	2.0	X	X		
LPN and LPE	7/20/65	PTA maintenance	2.0	X	X		
Tape 1	7/21/65	Channel 9 out — bad trimpot	0.5	X			
LPZ, LPN	7/21/65	Check and test PTA filters	6.0	X	X		
Z-14	7/22/65	PTA maintenance	1.0	X	X		
SPE	7/24/65	Electrical storm	1.0	X	X		
Microbarograph, Anemometer, Z-1, Z-2, Z-3, Z-4, Z-5, Z-6, Z-7, Z-8, Z-9, Z-10, Z-11, Z-12, Z-13, Z-14, Z-16, Z-19, SPN, SPE, IBZ, IBN, IBE, LPZ, LPN, LPE	7/25/65 to 7/26/65	Severe electrical storm; direct hit on tank farm and several array seismometers and cables. Most SP seismometers on line in about 12 hr IB's on line 7/27; LP's on line 7/29	As noted under cause	X	X		*
Develocorder	8/6/65	Galvo lamp out in secondary develocorder — no loss of primary data	6.0		X		
Develocorder (LP)	8/6/65	LP develocorder maintenance performed	5.0		X		*
SPE	8/9/65	Dragging coils	14.0	X	X		
SPN	8/10/65	Dragging coils	16.0	X	X		
LPN	8/17/65	PTA malfunction	24.0	X	X		
Tape 2	9/16/65	Capstan drive belts replaced	0.16	X			*
Develocorder	9/20/65	Pump malfunctioned on primary develocorder - loss of primary data	6.0		X		*
Develocorder	9/21/65	Developer lines plugged up - loss of primary data	5.0		X		*
LPZ	10/9/65	Main coil spring out of tolerance	3.0	X	X		
Z-3, Z-9, Z-19	12/5/65	Seismometer maintenance	8.0	X	X		
Power Control Unit	2/14/66	Relays burned out by previous lightning damage	3.5	X	X		*
Power Control Unit, Power Amplifier and DC-AC Inverter	4/6/66	Relays burned out by previous lightning damage	8.0	X	X		*
Data and Cal Cables to Z-1, Z-2, Z-4	6/17/66	Electrical storm — 11 cable breaks	12.0	X	X		
Cables to Z-6, Z-7, Z-18, Z-9	7/17/66	Electrical storm — 11 cable breaks	12.0	X	X		



maintenance procedures on seismic instrumentation during the reported period. As a result of this continuous effort the good, overall level of station maintenance is verified by the fact that no serious data loss has occurred during the period May through July (subsection II-D4 below), and that routine Quality Control has indicated minimal problems with tape and film data during this period (subsection II-F below).

2. Instrumentation Changes

Two significant instrumentation changes were accomplished during the reported period. Both changes were directed toward improving station data display and detection capability and were approved by the Project Officer.

a. Long Period PTA Filter

The PTA filter applied to horizontal and vertical long period data was changed from a Model 6824-2 to a Model 6824-15. The response of each is shown in Figure 1. As shown in this figure, the present response furnishes greater rejection of 4-to-6 sec period microseismic energy. As a result, signal-to-noise power* on the long period displays is significantly increased relative to the previous system since 4-to-6 sec period energy is the predominate noise contributor.

b. MCF Output Filters

The "smoothing filter" boards, through which the analog outputs of the MCF processor pass prior to display, were replaced with a revised board which improves display of develocorder data. The response of each filter is shown in Figure 2. The original filters rejected 15 to 25 cps energy at an average of 12 db which was insufficient to reduce the 20 cps spectral component resulting from D-A conversion below an observable level. This was manifest by:

- Noticeable digital sampling on develocorder data
- Noticeable beating of calibration signal above 2 cps with sideband energy of the 20 cps component

The present filter boards reduce these effects below visual detectability by providing an 18 cps notch filter which is flat in the 0 to 5 cps frequency band.

* Signal and noise power as used here refers to total power over the filter passband.

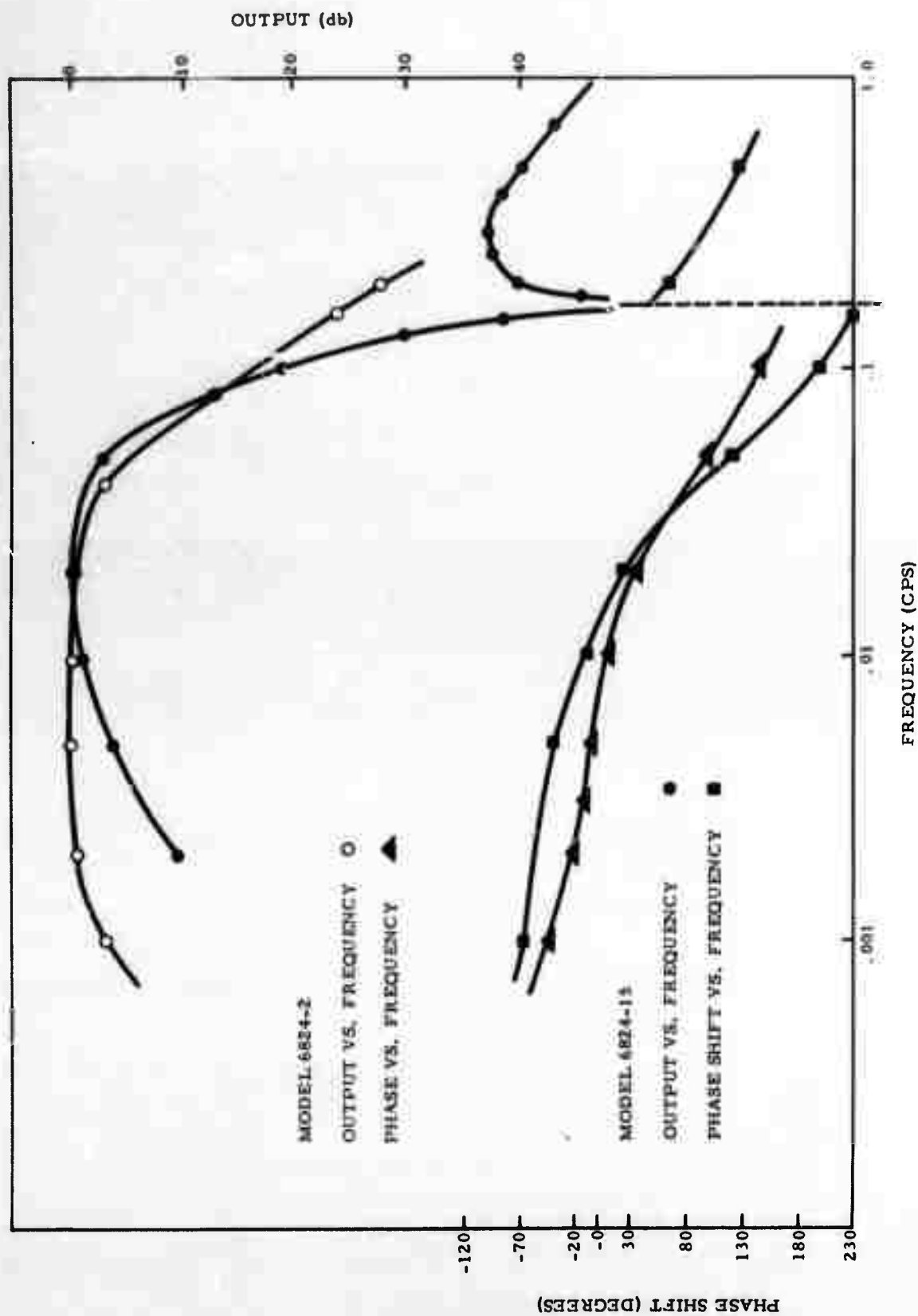


Figure 1. Response of Long-Period PTA Filters

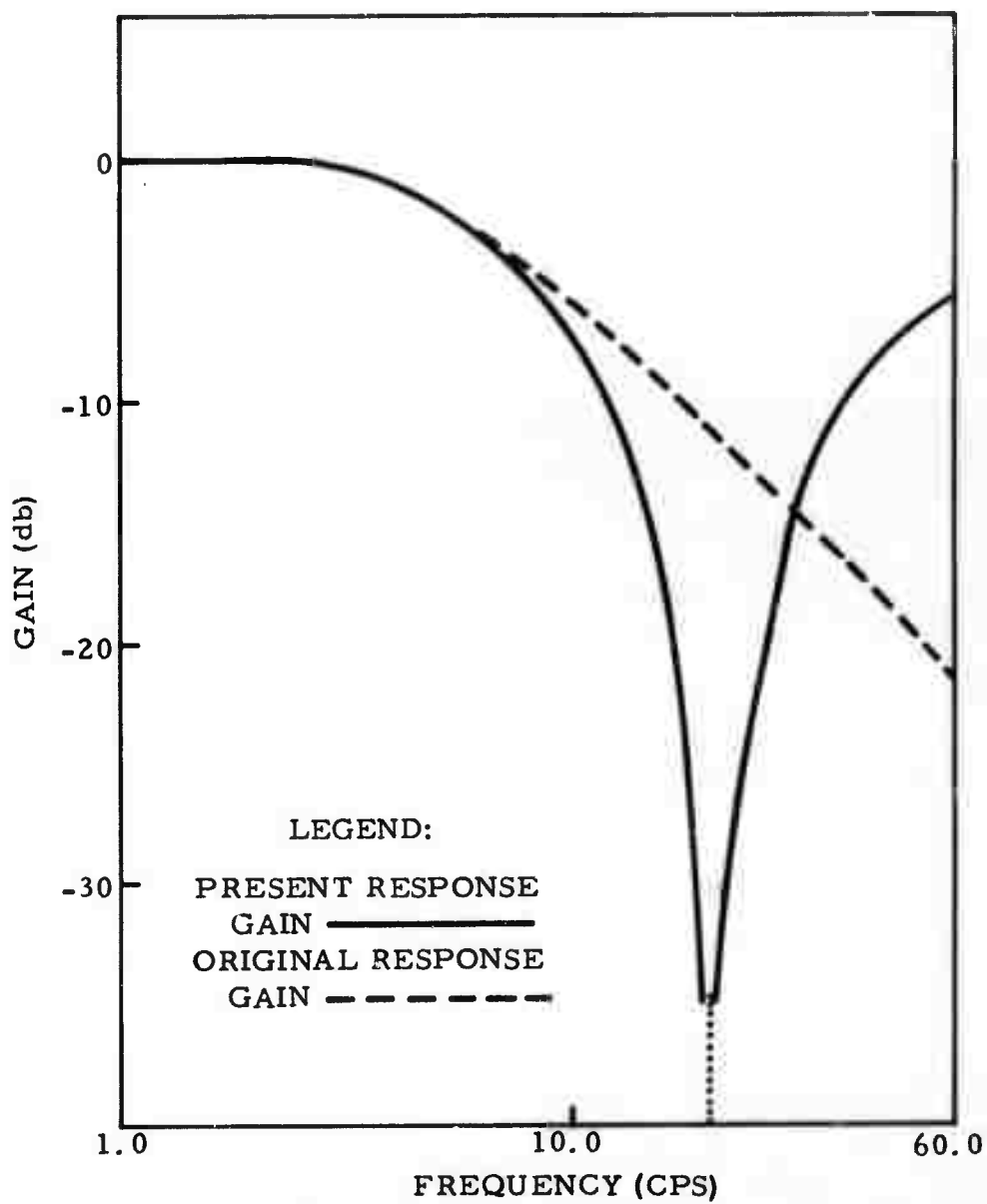


Figure 2. CPO MCF Processor Output Response



3. Major Accomplishments and Problems

Listed below by months through the report period are the major accomplishments and problems encountered. Where applicable, a brief explanation is provided.

a. May

- Conducted long-period frequency responses

b. June

- Strobe would not pick up pulses due to several faulty capacitors. The strobe was repaired and replaced on-line with no data loss.
- Modified programmer (timing system) to monitor 1 pps (one pulse/sec) output. This modification enables synchronization of timing system with WWV by using scope or strobe for increased accuracy.

c. July

- All long-periods checked and adjusted
- Replaced No. 1 develocorder with a unit rebuilt at the station
- Equalization performed on all short-period instruments
- Cables to Z-6, Z-7 and Z-18 damaged by lightning and repaired
- D-C pulses and equalization performed on all seismometers
- Z-9 PTA and power supply changed for maintenance
- LPZ, LPE and BBZ recentered and adjusted at vault
- Anemometer and microbarograph checked for proper operation and recalibrated
- Coefficient loss by DMCF due to electrical storms
- Installed smoothing filter boards in DMCF



In addition to the above problems, difficulty was experienced with coefficient losses in the MCF processor. These coefficient losses are discussed in detail in subsection II-E.

4. Analysis of Station Down-Time

The effectiveness of the station as a monitor of seismic events is inversely proportional to the percentage of station down-time. To show this effectiveness, a detailed list of all station down-times from 1 May 1965 to 31 July 1966 has been compiled. This list (Table 1) presents the unit affected, the date of the down-time, the cause of the down-time, the length of the down-time, and the type of data loss. The asterisks in the last column indicate periods of serious data loss; i.e., the station was at least partly useless as a data gathering installation.

Using the results presented in the table, the following figures were obtained to show the percentage of down-time to total operating time over the 15-month period:

- Serious data loss - 0.45 percent
- Total down-time - 2.99 percent

Of significant interest is the fact that, of the 37 down-times listed, 31 occurred on or before 30 September 1965, and only two of them occurred during this quarter. These facts show the improved operating configuration obtained by station personnel during the contract period and especially during the reporting period. The results also show that the station has been very effective as a seismic monitor since there were only 12 times during the 15-month time period when the station had incurred a serious data loss, and those times amounted to only a very small percentage of the total possible recording time.

Also from the table, the following key points are evident:

- Four of the last 14 serious problems have been due to develocorder malfunctions. To remedy this, station personnel have initiated an on-site overhaul program in which a spare develocorder is used to allow the unit being overhauled to remain off-line.
- Two of the last four serious data losses were caused by power control unit failures. To curtail future occurrences of this problem, station personnel are



replacing all bad relays which have been damaged by lightning storms. Also a modification is being considered which will reduce the time of data loss incurred if the problem occurs again. This modification comes from the vendor who suggests that a board be installed in the power control units. This board will contain plug-in type connectors which will allow station personnel to repair the unit without taking all of the station off-line. Since the present unit contains screw-in type relays, this modification will be accomplished if a spare unit can be obtained.

E. DMCF MAINTENANCE AND RELIABILITY

With regard to the processor evaluation study, Table 2 is presented to show the processor failure times and data loss for the period March 1966 to July 1966.

Table 2
PROCESSOR FAILURE TIMES AND DATA LOSS

Month	Memory Loss	Routine P.M.	Other Maintenance	Summary
March	1.23	0	0	1.23
April	4.30	0	6.39	10.78
May	0	0.89	54.64	55.53
June	0	3.47	0	3.47
July	0	0	0.53	0.53

Numbers in Table 2 represent the percentage down-time relative to total possible running time (i. e., one month time period). Categories are defined as follows:

- (1) Memory Loss — Loss of all coefficients in memory. When time of memory loss was not known, a standard 4-hr down-time was used in the computation. This time represents 1/2 the time the processor remains unattended (i. e., over one night).
- (2) Routine Preventative Maintenance — Maintenance as described in the processor handbook which includes basically cleaning air filters, replacing ribbon, and printer paper, reprogramming, etc.
- (3) Other Maintenance — Includes all other categories such as testing, component replacement, etc.



The large percentage of down-time noted through May was due to problems concerning the data-saver portion of the Fabritek Memory. During May the MCF was down for approximately 2 weeks while TI engineers and a Fabritek factory representative performed testing and the following maintenance:

- Replacement of marginal components
- Readjusted the schmoo diagram
- Resolved bad joints on the delay line boards in the memory
- Replaced the data-saver board
- Added a 4-v monitoring circuit to the power supply
- Replaced the 8000 μ f capacitors in the power supply

Not included in the reliability data are those periods in which there was a coefficient loss. This type of loss has historically affected only a few coefficients at most, and these have been normally from only one or two of the MCF outputs. Thus, during these periods, the processor has been operational with the exception of one or two outputs.

The percentage of run time in which the coefficient loss problem has affected performance of at least one MCF output is as follows:

- March — 0 percent
- April — 6.67 percent
- May — 5.0 percent
- June — 1.22 percent
- July — 0.94 percent

For those periods which the time of coefficient loss was not known, a standard 4 hr was used for the reasons presented in (1) on the previous page.



At present, the coefficient loss problem appears to be the only remaining area which requires continued investigation. To date, it has been demonstrated that there is good correlation between this loss and lightning storms, or equivalently, line transients. The grounding system within the processor has been modified so that all subsystems utilize a common ground, and the input line power has been changed so that the MCF and associated instrumentation (i.e., PTA's, develocorders, etc.) work off a common source and, consequently, have a common external ground. Additionally, gas-charged lightning protectors, similar to the AEI units, will be installed at the station input power point to eliminate high-speed line transients.

F. QUALITY CONTROL

The overall quality of film and magnetic tape has ranged from good to excellent. Film quality has been improved by replacing develocorder No. 1 with another develocorder that was overhauled by station personnel.

The different areas of quality control are discussed in CPO Annual Report No. 1.* Basically, those areas include:

- Develocorder Film Quality Control
 - Check control post analysis forms for completeness and legibility
 - Check daily calibration logs for completeness
 - Compare film quality with comments in calibration logs
 - Check data with analysis forms for missed events, phase identifications, event measurements, and calibration measurements
- Magnetic Tape Quality Control
 - Check for tape system noise
 - Check for tape alignments
 - Check calibrations for relative amplitudes, signal levels and phases
 - Check time codes and WWV

* Texas Instruments Incorporated, 1966, CPO Annual Report No. 1, VT/5054, AFTAC, 15 Sept.



Examples of quality control reports are as follows:

- Quality Control of Magnetic Tapes
 - Wow and flutter on tapes from both transports measured up to specifications
 - Dynamic range of tapes measured 55 to 56 db with compensation
 - Timing of VELA time code and WWV were both good and together in time
 - Average frequency measurements of the tapes show all channels to be within ± 1 to 2 cycles from center frequency
 - On seismometer calibrations all channels are in phase and no deviation reported between channels
 - General conditions of tapes showed very few spikes
- Quality Control of Develocorder Film
 - Analysis for months of May, June and July was good on the days checked
 - Log completion was neat and accurate
 - The thoroughness of analysis from completion was good



SECTION III RESEARCH

A. GENERAL

The research planned for the present contract year, 1966-1967, is basically an extension of the previous years' work* in that improvement of station detection capability is the ultimate objective. Specifically, the following tasks will be accomplished:

- Continuation of Ambient Noise Study

This study will be continued to insure that the spatial organization of the key noise field contributors will remain unchanged. This will generally indicate the suitability of the MCF's (which are based upon previous measured noise statistics) applied on-line. This task is accomplished by computing and analyzing single-channel power density spectra and multidimensional frequency-wavenumber spectra. It should be noted that this method is ineffective in showing only slight changes in the noise field since they will be obscured by the large peaks in the spectrum.

- Auxiliary Processor Design and Construction

Involved in this task are the design and construction of a real-time, on-line detection and identification processor which will interface with the digital MCF at CPO. The processor will simultaneously compute and output for recording Wiener power, UK and Fisher statistics, and also provide threshold detector output. In conjunction with this system, a simulation program is being written to check the processor operating parameters and truncation errors. Research will be conducted on the various processes using this program to determine the effects of certain assumptions, i.e., noise correlation, on the output data.

* Ibid.



- **MCF Evaluation Study**

The objective of the MCF evaluation is to determine the degree of increased detection capability afforded CPO through the addition of the MCF processor. The study is analyst-oriented and will involve a comparison of the number of signals detected by analysts using raw and MCF processed data. Curves will also be computed on a monthly basis for each processor output.

- **Visual Data Display Improvement**

Research on this task is in the planning stage at present. Proposed research includes the study of several techniques to determine the improved methods for enhancing visual data display. One approach under consideration includes developing single-channel filters to remove various system response parameters over specified frequency bands. Implementation of these filters will be accomplished on-line through use of the digital MCF. Another method includes the application of various trace display techniques, i. e., variable area and variable density displays.

Subsection III-B presents the results of research efforts conducted during the reported quarter.

B. AMBIENT NOISE STUDY

The purpose of this section is to compare the properties of the present CPO ambient noise field with those previously observed for May 1965 through April 1966 in order to determine if changes in spatial configuration have occurred which would affect the MCF performance. Future research on this task calls for continuance of the study through April 1967 with the computation of one single-channel power density spectra per week and one set of frequency-wavenumber spectra per month.

During the reporting period, May and June data have been completely processed, and results and conclusions are presented in the following paragraphs. July data has been selected and is in processing.



1. Single-Channel Power Density Spectra

Figure 3 shows the CPO ambient noise single-channel power density spectra for 2 May 1966 and 6 June 1966 as computed from the Z10 short period sensor output. These spectra were analyzed for significant variations over the frequency band 0.1 to 4.0 cps by comparing absolute noise levels against previous results*.

Results of this comparison show that the ambient noise level has not changed significantly from previous results during this quarter. Variations due to microseismic storms at the lower frequencies are observable as before. This result is clearly shown when the spectra for 2 May 1966 is compared with the spectra for 3 October 1965*, and when the spectra for 6 June 1966 is compared with that for 14 September 1965*. These two sets of spectra exhibit very nearly the same form and show approximately the same power levels at corresponding frequencies. Of particular interest is the similarity of the power distribution in the 0.1 to 1.0 cps frequency band and at the 1.4 cps and 1.9 cps power peaks since these frequencies are generally the most predominant contributors to the power density spectra.

2. Frequency-Wavenumber Spectra

The data presented in the 3-dimensional frequency-wavenumber spectra shown in Figures 4 through 7 does not differ from representative data taken on 6 August 1965 and 28 September 1965 and presented in CPO Quarterly Report No. 3, pp. III-4 to III-7.*

Of particular interest is the similarity in power lobes labeled 4, 11 and 18 since these are the major contributors to the ambient noise field. Comparing Figure 4 of this report with Figure III-2 for Quarterly Report No. 3*, one notices the similarity between the 18 lobes in the 0 to -3 db power range. Similarly, the following comparisons may be made:

- Lobes 4 and 11 for Figure 5 of this report and Figure III-3 from Quarterly No. 3
- Lobe 18 from Figure 6 of this report and Figure III-4 from Quarterly No. 3
- Lobes 4 and 11 from Figure 7 of this report and Figure III-5 from Quarterly No. 3

*Texas Instruments Incorporated, 1966: CPO Quarterly Report No. 3, VT/5054, AFTAC, 29 March.

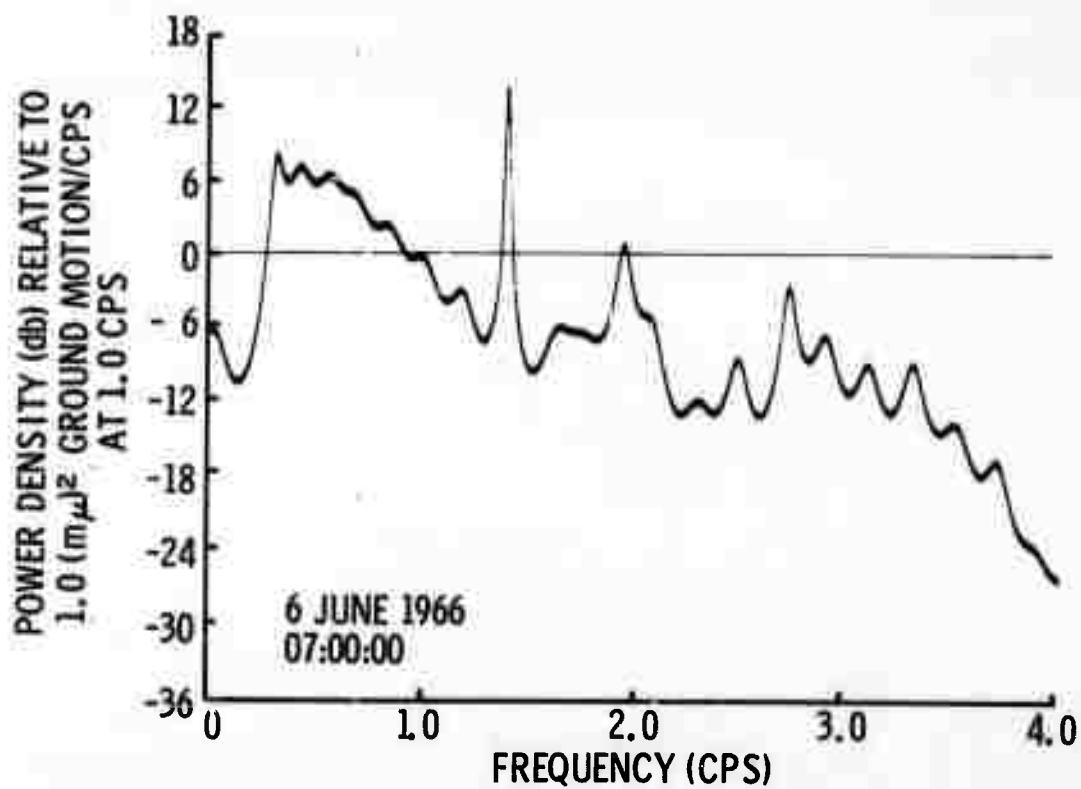
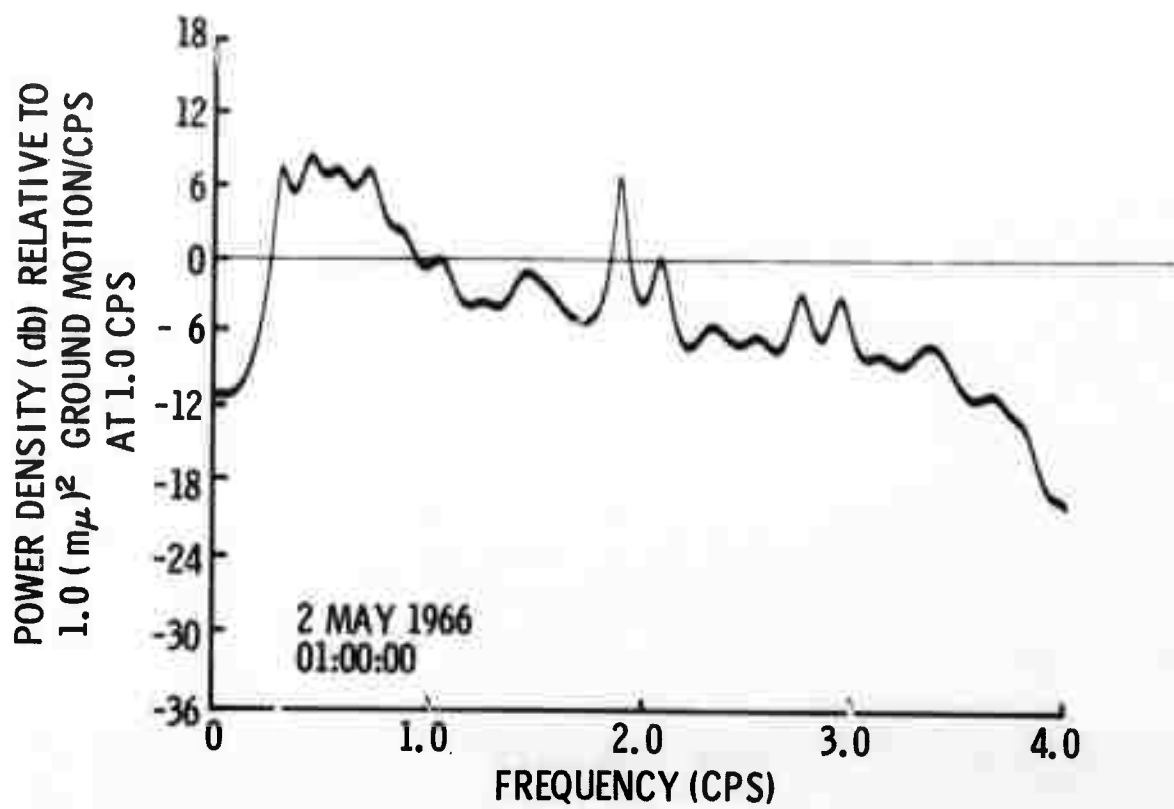


Figure 3. CPO Ambient Noise Power-Density Spectra for May 2, 1966 and June 6, 1966

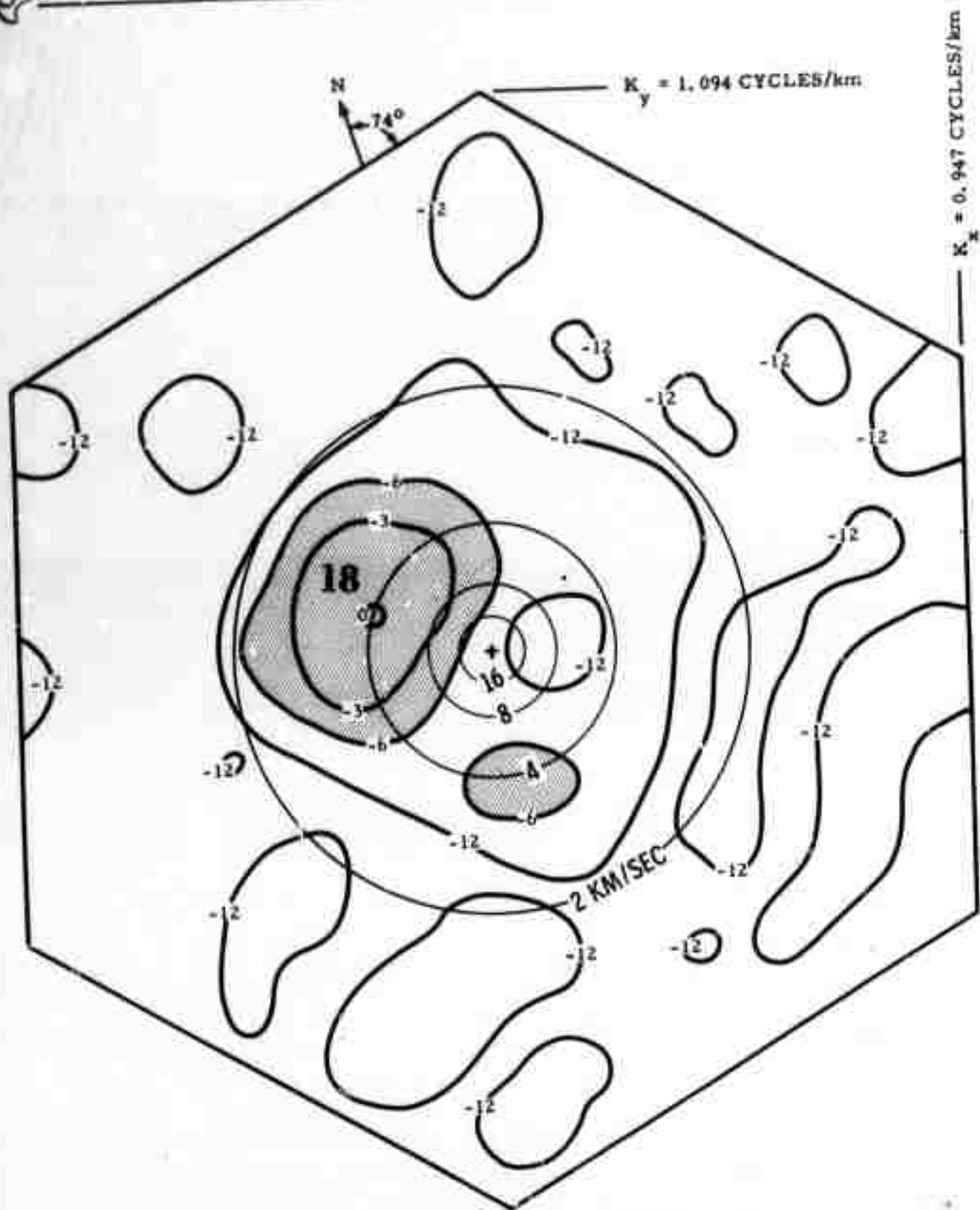


Figure 4. CPO Ambient Noise Frequency-Wavenumber Spectrum May 2, 1966
($f = 1.00 \text{ cps}$)

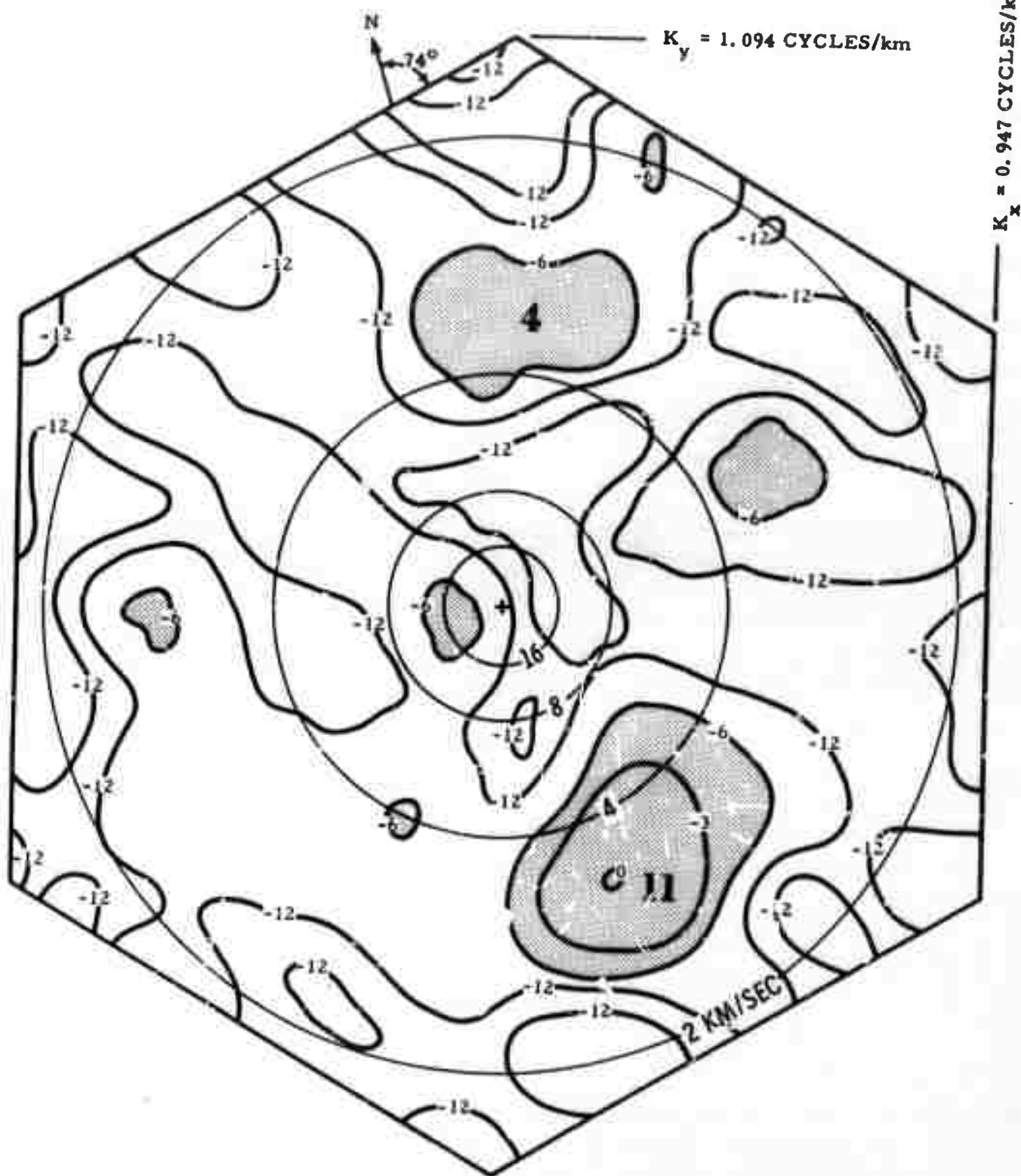


Figure 5. CPO Ambient Noise Frequency-Wavenumber Spectrum May 2, 1966
($f = 1.75$ cps)

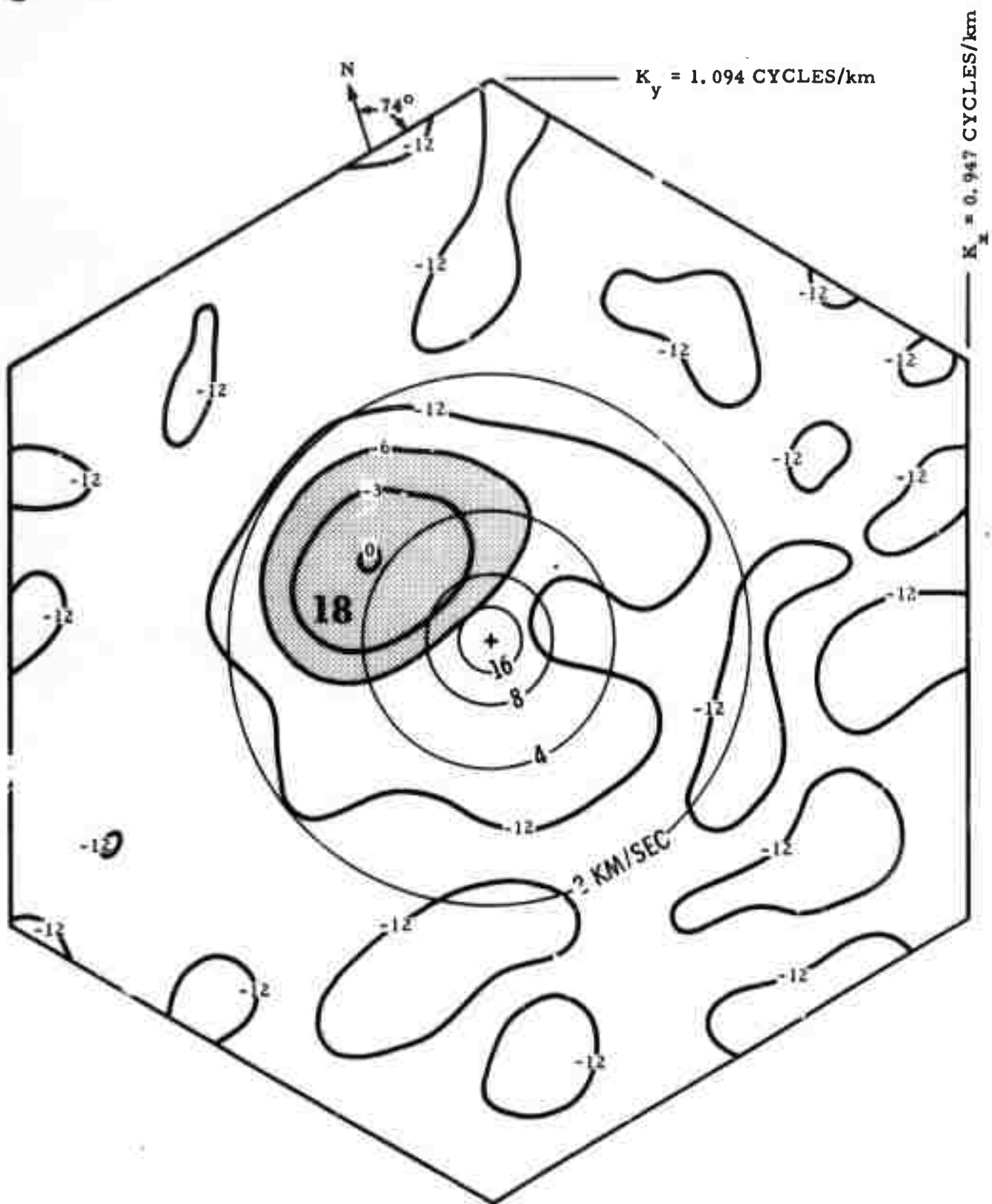


Figure 6. CPO Ambient Noise Frequency-Wavenumber Spectrum, June 6, 1966
($f = 1.00$ cps)

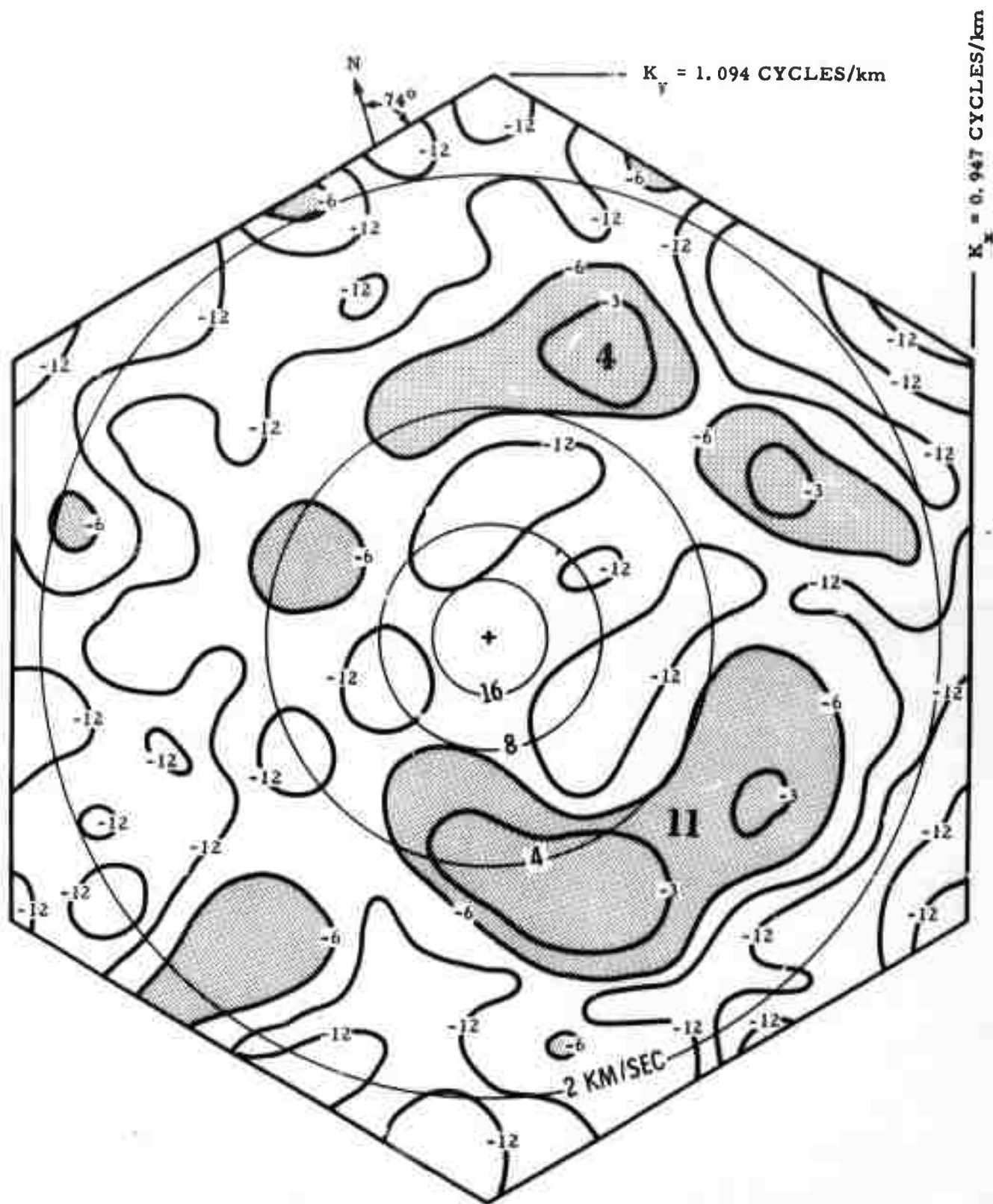


Figure 7. CT Ambient Noise Frequency-Wavenumber Spectrum, June 6, 1966
($f = 0.75$ cps)



3. Conclusions

The results presented in this section show that the ambient noise field, as described by single-channel power density spectra and frequency-wavenumber spectra, has not changed significantly from the field modeled in the previous contract year. Hence, the filters developed during the first contract year for use in the DMCF appear to be accurate for normal level noise days.

C. DETECTION AND IDENTIFICATION PROCESSING

1. Research Activities

The research effort for this task has been directed thus far toward the development of an auxiliary processor computer simulation program. Upon completion, this program will be used to verify processor logic, evaluate truncation errors introduced at various points in the processor, and study various operating parameters to be used in the processor when it is installed at CPO. Primarily, the program will be used in performing basic research on the different processing techniques. This research will include investigative work to determine the effect of assumption violations resulting from the fact that the ambient noise field is spatially coherent to a degree while two of the processes, the Fisher and UK, assume the ambient noise to be uncorrelated in space.

During this quarter, all of the program logic, except for the Fisher divide routine, has been developed into various subroutines. Upon completion of divide routine, all of the subroutines will be interconnected to form the simulation program. At present, work is also underway on the input subroutine, which will be used to read in the various operating parameters, and the output subroutine, which allows the data to be placed on magnetic tape which will be plotted on a Calcomp Plotter and/or printed to allow for a detailed analysis of the various operating parameters and the roundoff errors.

2. Processor Design and Construction

Work has progressed satisfactorily on the design and construction of the Detection and Identification Processor. As of 31 July 1966, construction was approximately 42 percent complete. Also, work on the engineering portion of the handbook and the preliminary copy of the acceptance test is well underway, and work has begun on the drawer wirings and the modification instructions.



as follows:

At present the schedule for completion of the processor is

- 26 September 1966 - Begin checkout
- 1 November 1966 - Begin mating of digital MCF and Auxiliary Processor
- 1 December 1966 - Complete checkout
- 15 December 1966 - Complete acceptance test
- 16 December 1966 - Begin preparations for shipment to CPO
- 30 April 1967 - Complete evaluation of the processor
- 15 May 1967 - Publish special report on evaluation of the processor

D. MCF EVALUATION

1. Introduction

To study the effectiveness of the Digital MCF as an on-line detection instrument, a study was undertaken to compile two lists of reported events.

- List 1 includes all events identified by CPO analyst personnel primarily using the MCF output and using the summation, horizontal and long-period trace outputs as back-up data to prevent reporting extraneous spikes as events.
- List 2 was compiled from the primary data and the summation traces from the secondary data. Comparison of the two lists would indicate the degree of improvement in station detection capability gained by using the MCF. The two complete lists for the month July 1966 are shown in Appendix A.



2. Presentation of Data

Table 3 shows the number of events reported on each of the above lists for July and the percentage increase in the number of events reported using the MCF output. From this table, the following results are observed.

- Processor results showed an increase of 195 events or 63.725 percent
- Without using the processor data, 306 events were reported which closely agrees with the average number of events (305) reported by station personnel from May 1965 to February 1966. The processor was installed at CPO in March 1966. This indicates that the increased number of events shown in the DMCF data is not due to an increase in seismic activity.

3. Discussion of Results

The results presented in Table 3 indicate that the MCF has increased the number of observable events at CPO. Also, as shown in subsection III-D-2, this increase is due to an increase in detection capability rather than an increase in seismic activity.

Figures 8 through 17 are presented to point out the type of events which station personnel detected only on the MCF output. These figures demonstrate the advantage afforded the station personnel by the MCF outputs compared to normal station data. Station time of the P arrivals is shown by the small arrows, and the first motions of the P arrivals on the DMCF output, which is delayed by 0.85 sec*, is shown by the larger arrows in the figures.

*

This delay is primarily due to the 2-sided filters used in the processor. The processor delay time is shown by the second break in the last trace on the secondary records. The station time, as shown by the first break in the same trace, lines up with the time marks displayed across the record.

Table 3
CPO DMCf OUTPUT STUDY FOR JULY 1966

Date	Number of Events Reported Without DMCf Data	Number of Events Reported With DMCf Data	Percent Increase In Number of Reported Events
July 1, 1966	14	19	7.14
2	No Data Available	8	-
3	11	19	72.73
4	15	23	53.33
5	9	17	88.89
6	5	8	60.00
7	5	6	20.00
8	11	15	36.36
9	7	13	85.71
10	9	22	144.44
11	15	23	46.67
12	8	23	137.50
13	14	19	78.57
14	20	25	15.00
15	12	23	50.00
16	5	18	320.00
17	12	21	33.00
18	4	16	55.55
19	No Data Available	14	-
20	17	15	41.18
21	No Data Available	24	-
22	9	31	100.00
23	19	18	89.47
24	15	36	40.00
25	10	21	40.00
26	15	14	73.33
27	8	26	25.00
28	10	10	60.00
29	8	16	112.50
30	4	17	150.00
31	10	10	30.00
Total	306	501	

* Total does not include result for days when no data available for column without DMCf Data

science services division

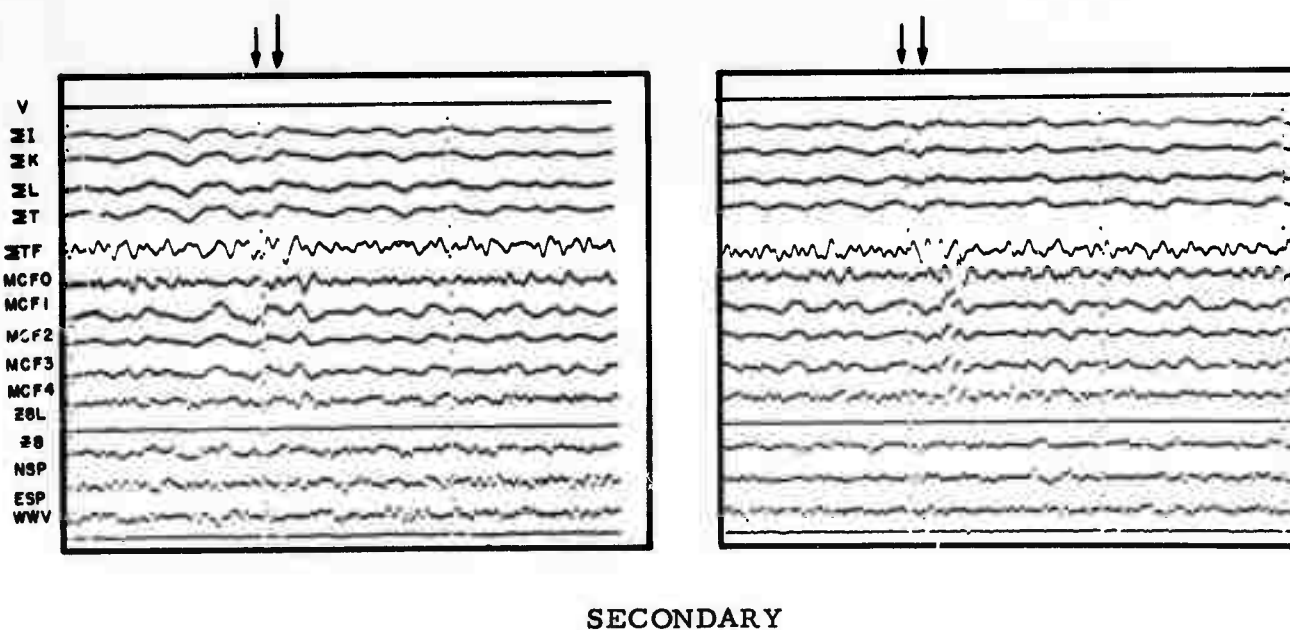
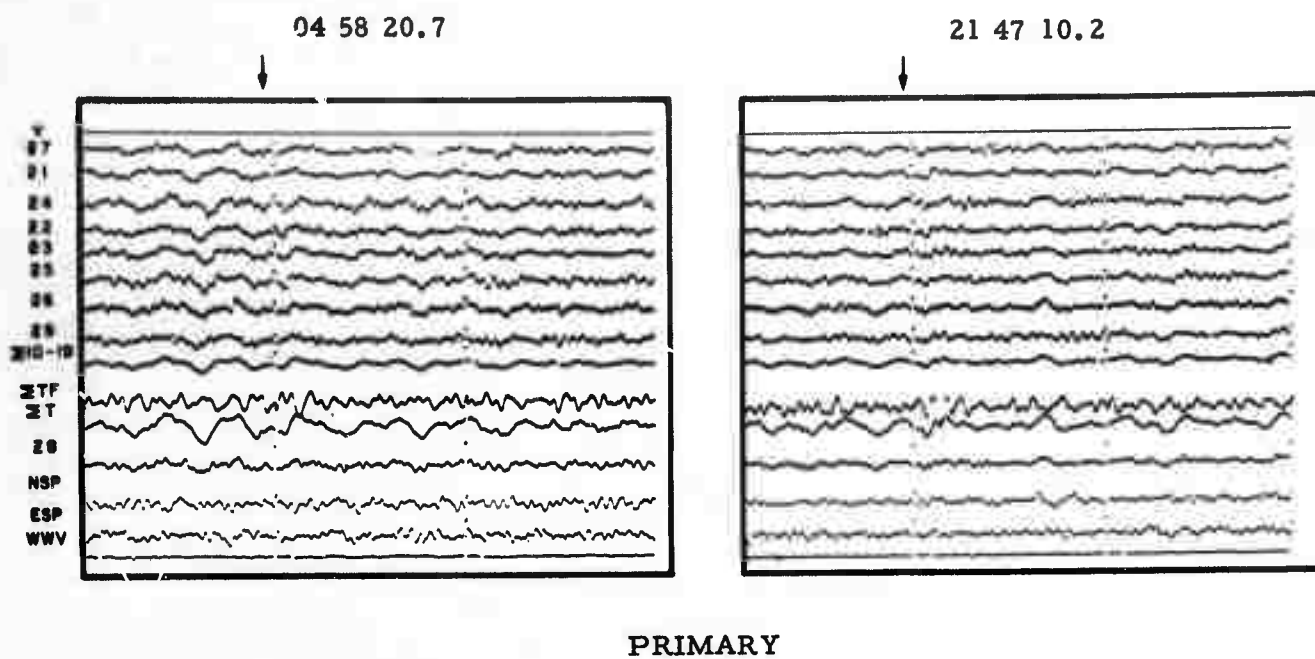
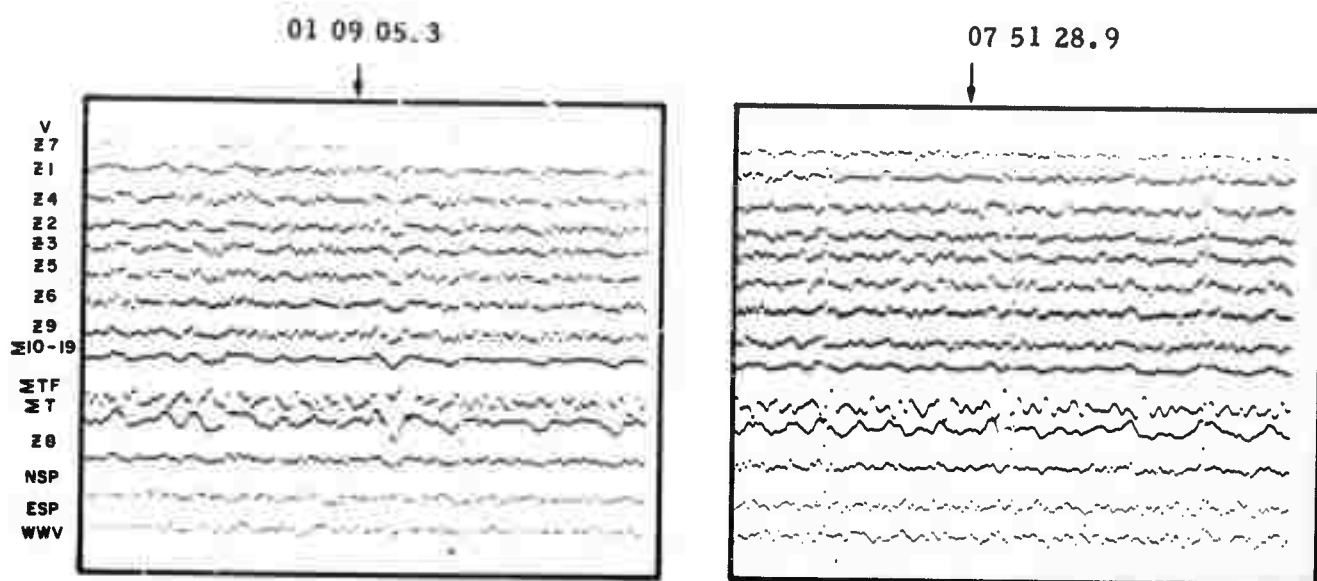
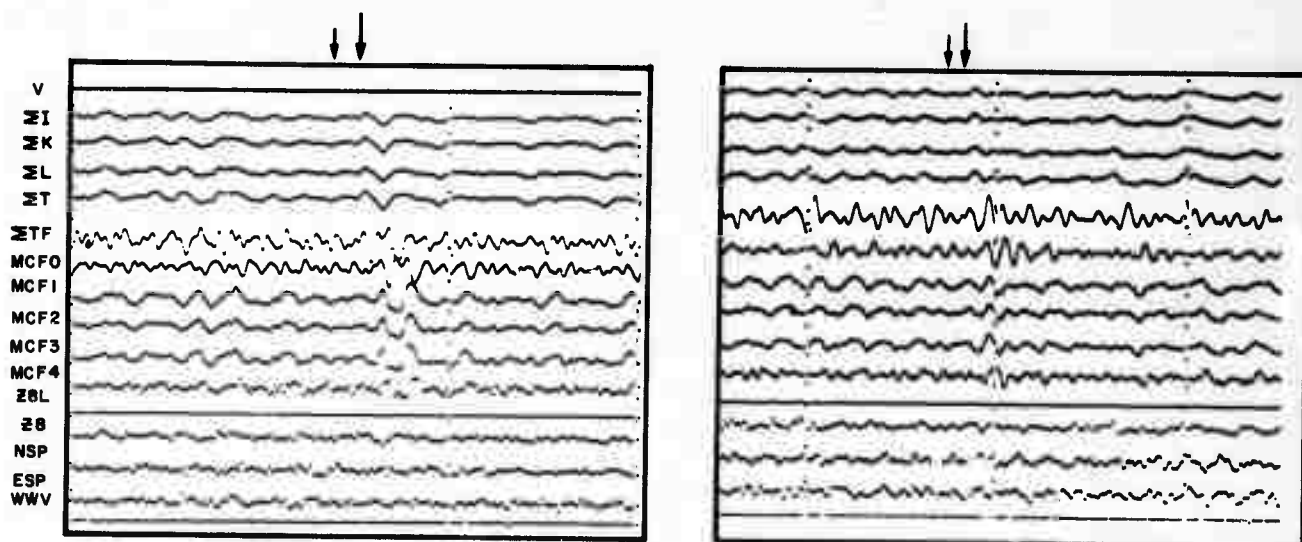


Figure 8. CPO Primary and Secondary Develocorder Records



PRIMARY

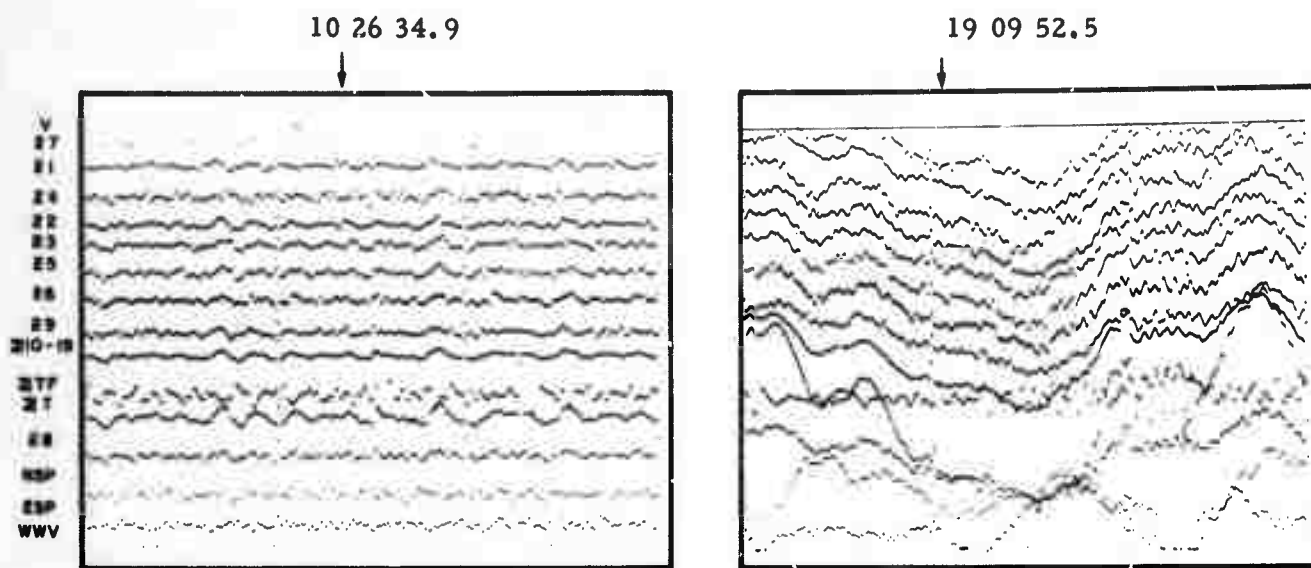


SECONDARY

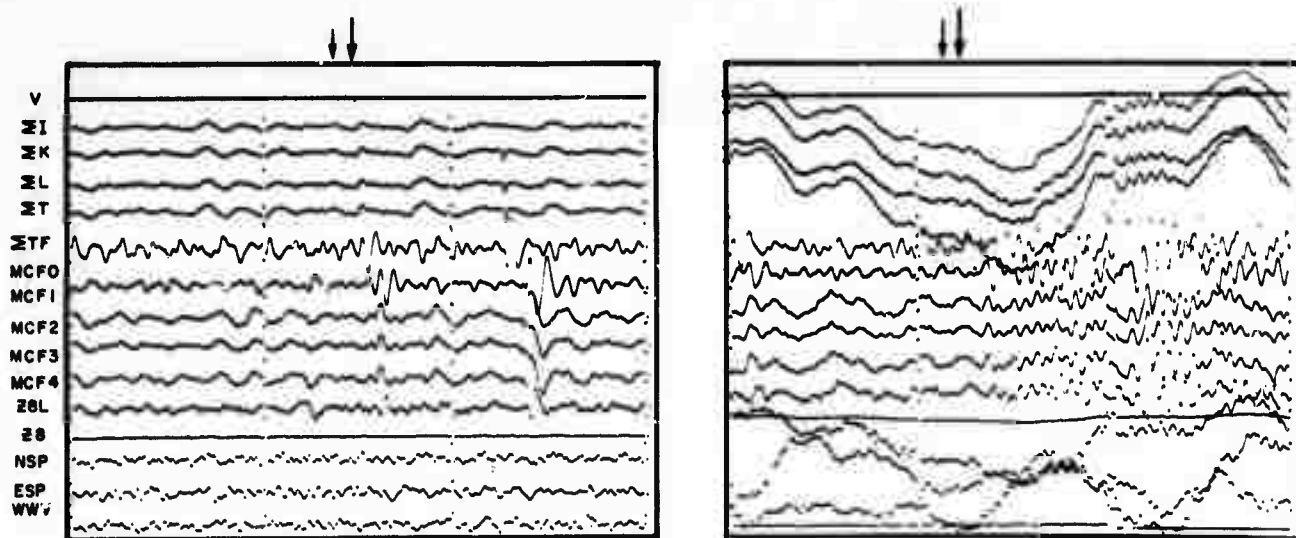
JULY 4, 1966

JULY 4, 1966

Figure 9. CPO Primary and Secondary Develocorder Records



PRIMARY



SECONDARY

JULY 4, 1966

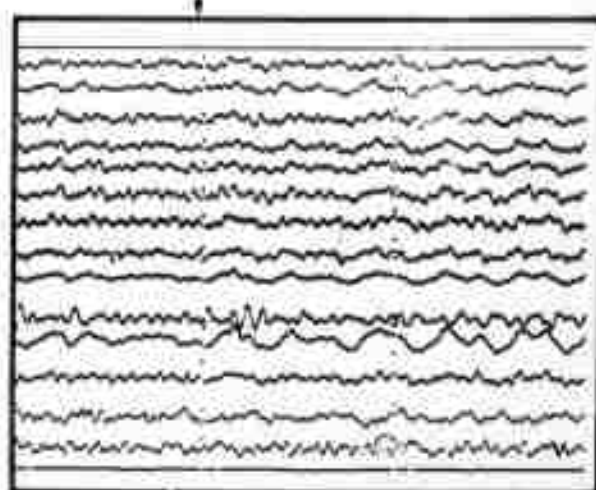
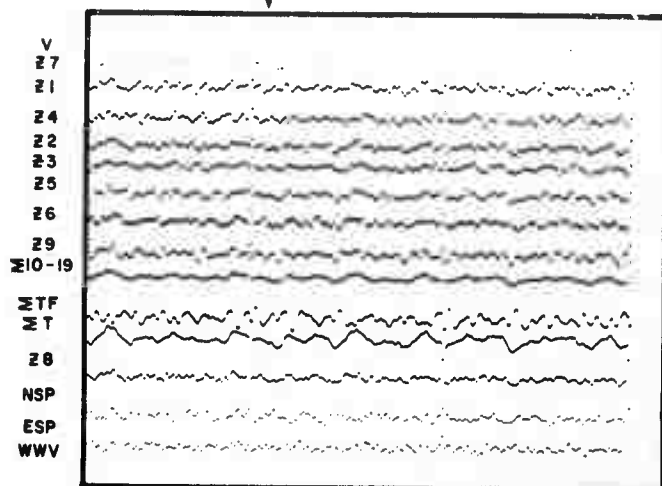
JULY 4, 1966

Figure 10. CPO Primary and Secondary Develocorder Records

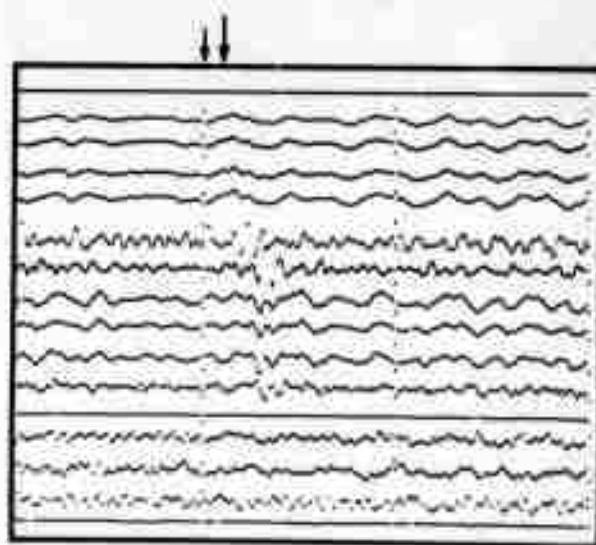
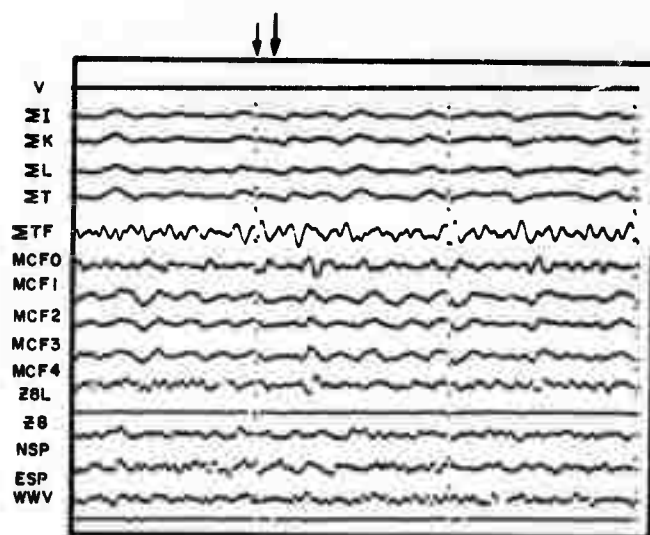


05 57 11.9

05 52 31.0



PRIMARY



SECONDARY

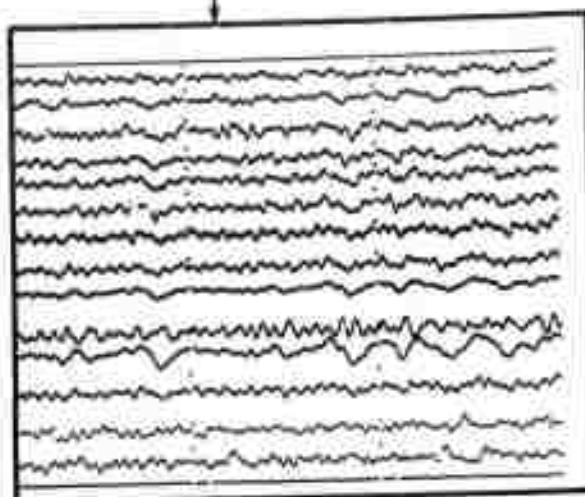
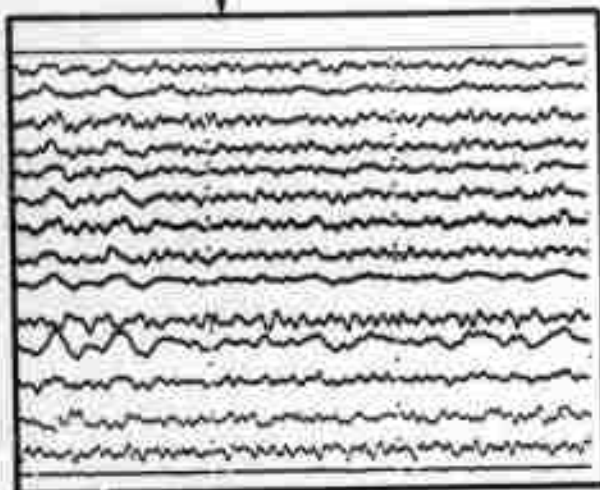
JULY 4, 1966

JULY 5, 1966

Figure 11. CPO Primary and Secondary Develocorder Records

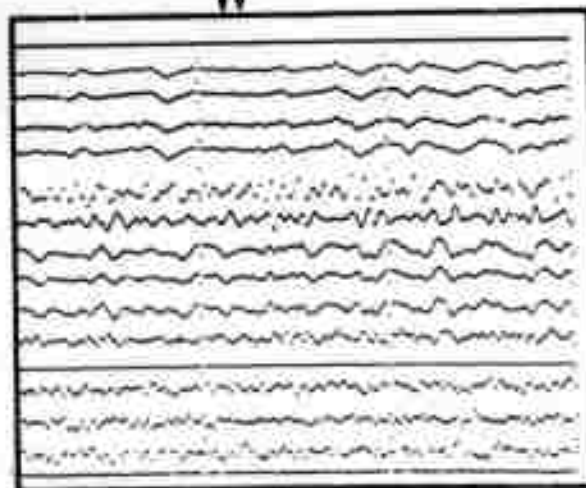
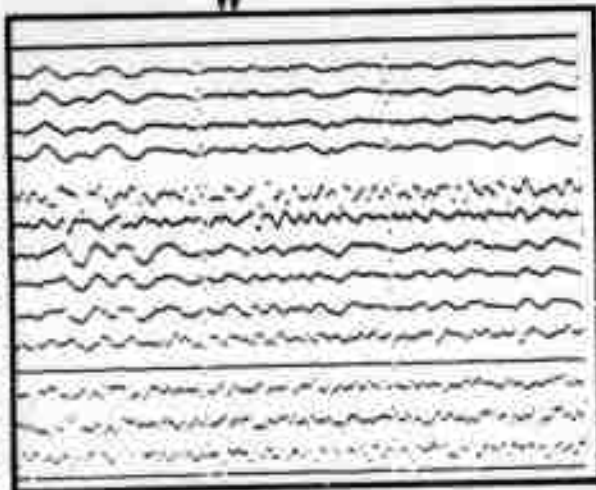
04 39 12.9

V
Z7
Z1
Z4
Z2
Z3
Z5
Z6
Z9
Z10-19
ZTF
ZT
Z8
NSP
ESP
WWW



PRIMARY

V
31
34
2L
3T
2TF
MCP0
MCP1
MCP2
MCP3
MCP4
SEL
SS
HSP
ESP
WSP



SECONDARY

JULY 5, 1966

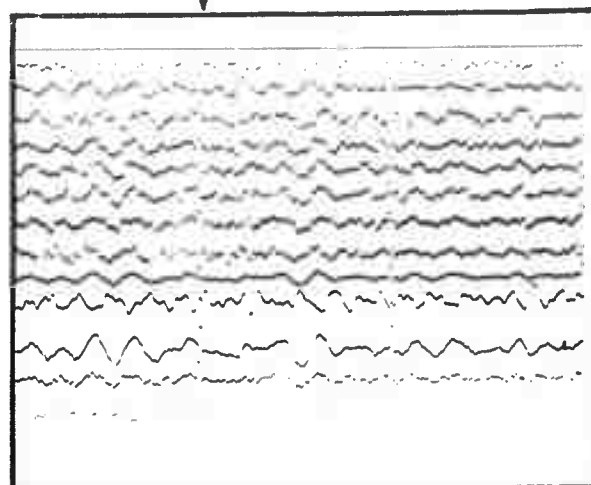
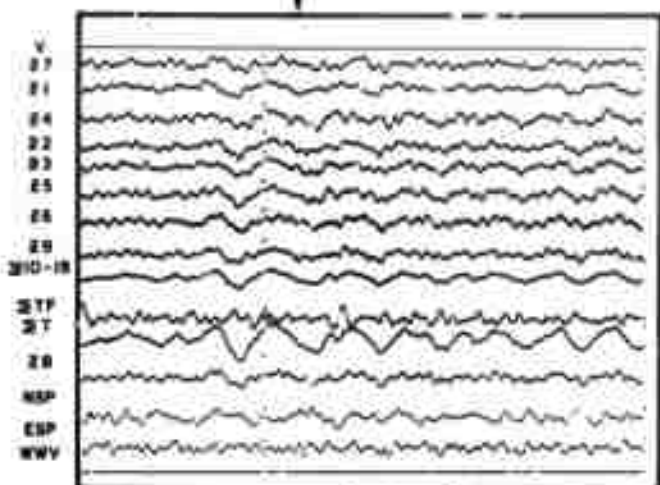
JULY 5, 1966

Figure 12. CPO Primary and Secondary Development Records

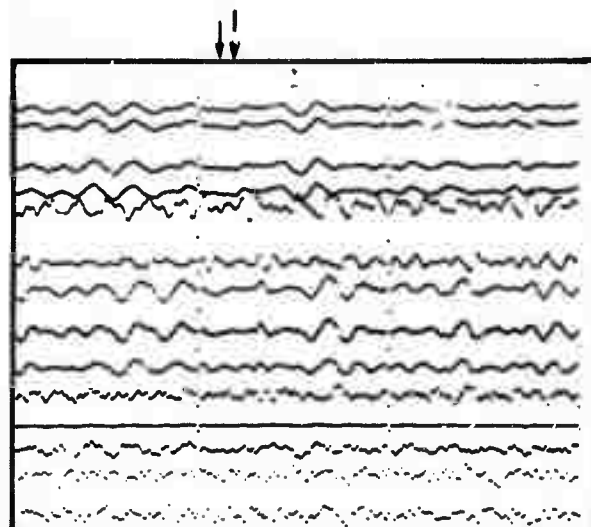
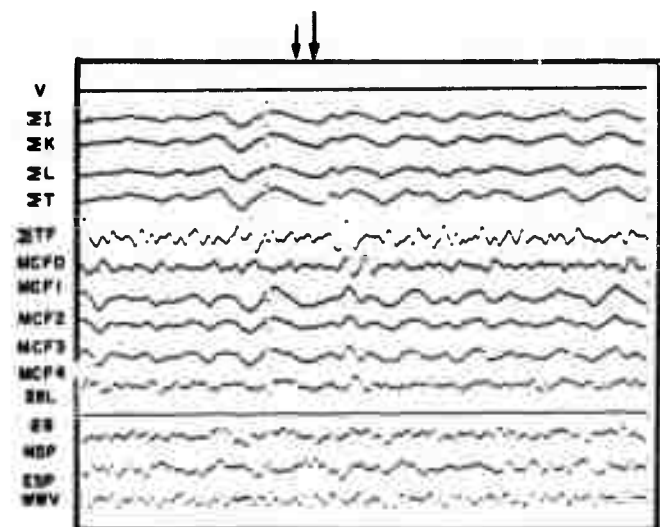


09 10 53.0

00 34 22.0



PRIMARY

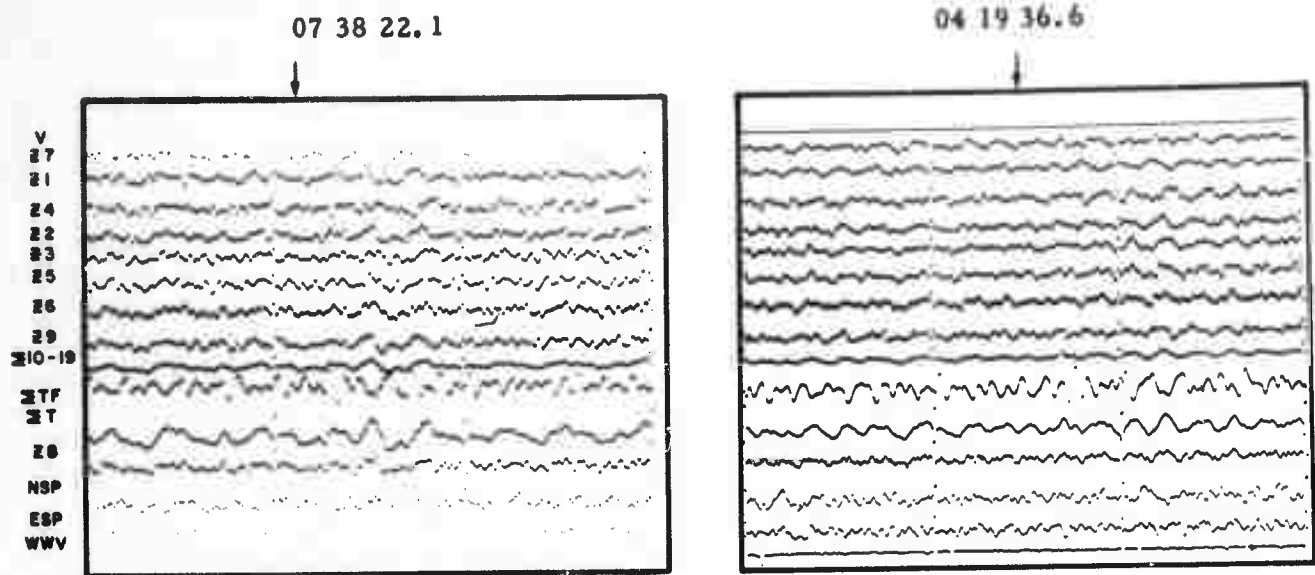


SECONDARY

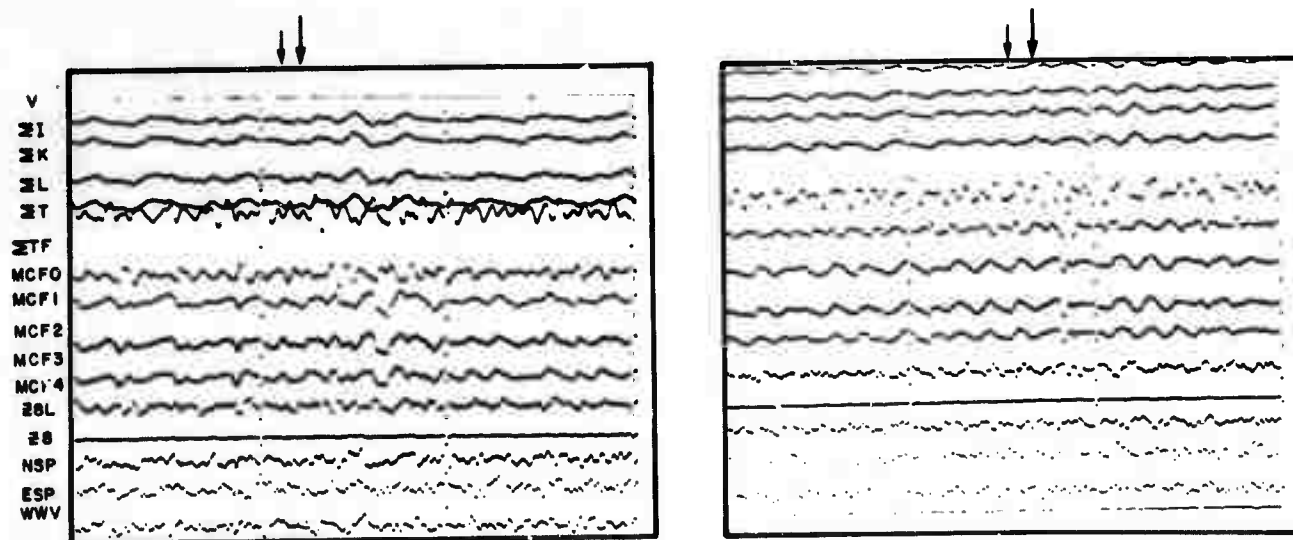
JULY 5, 1966

JULY 8, 1966

Figure 13. CPO Primary and Secondary Develocorder Records



PRIMARY

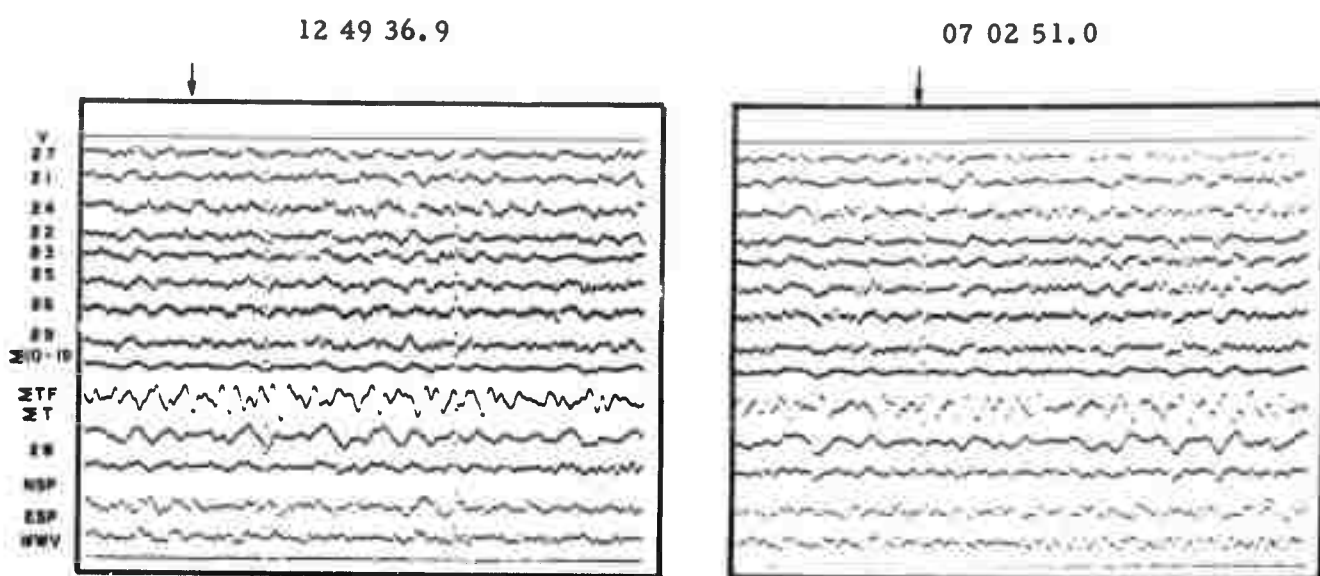


SECONDARY

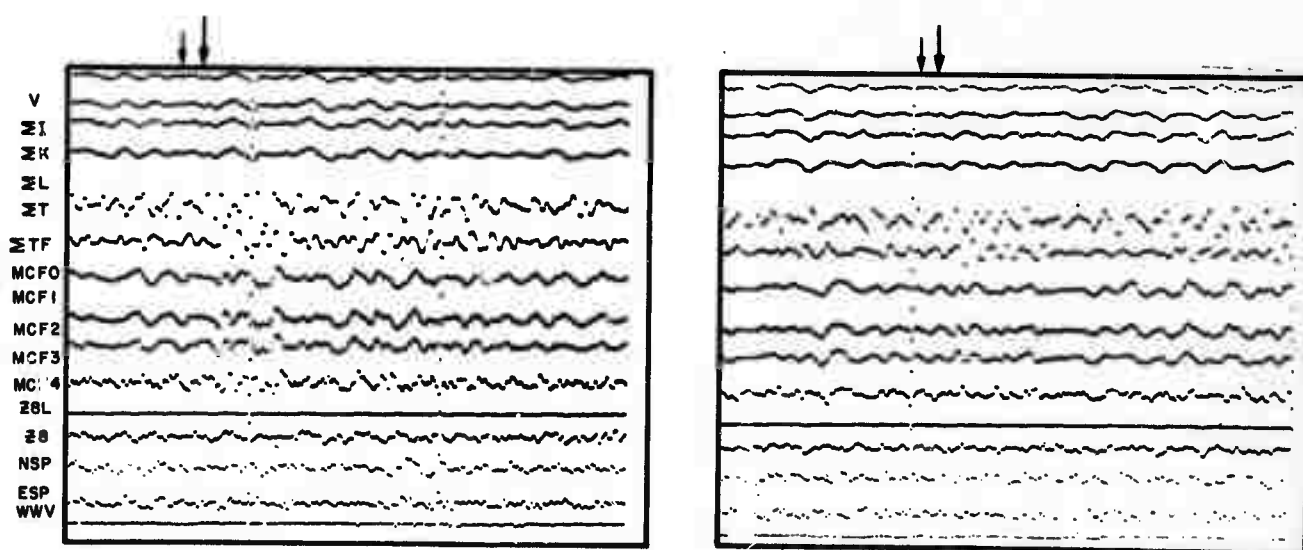
JULY 8, 1966

JULY 9, 1966

Figure 14. CPO Primary and Secondary Develocorder Records



PRIMARY

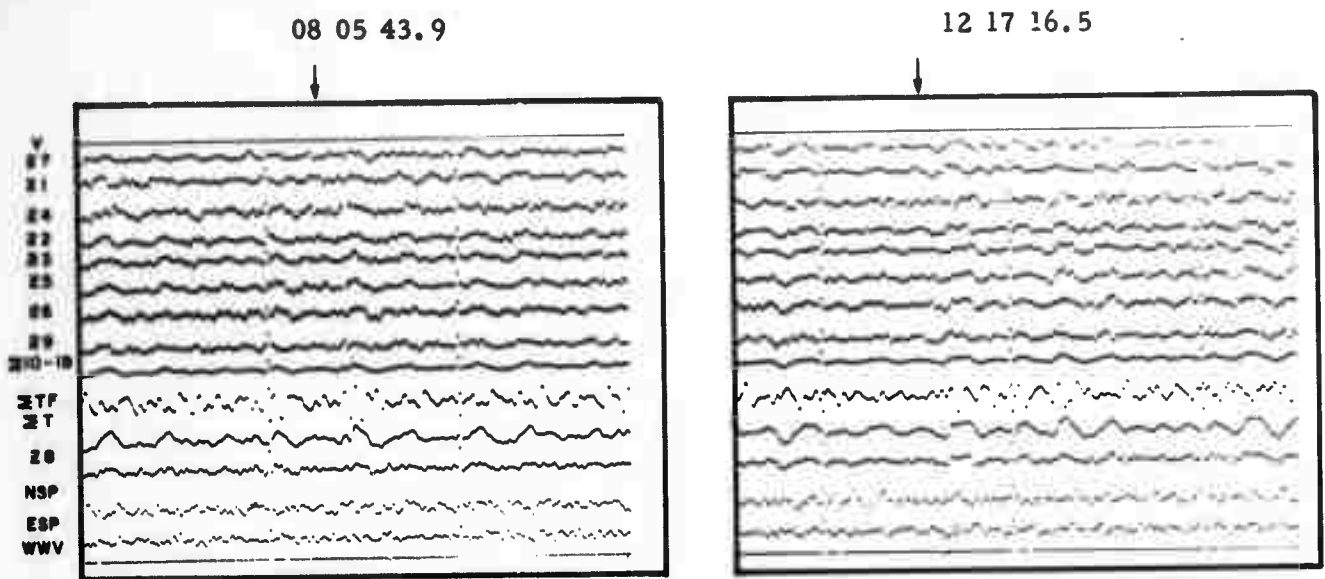


SECONDARY

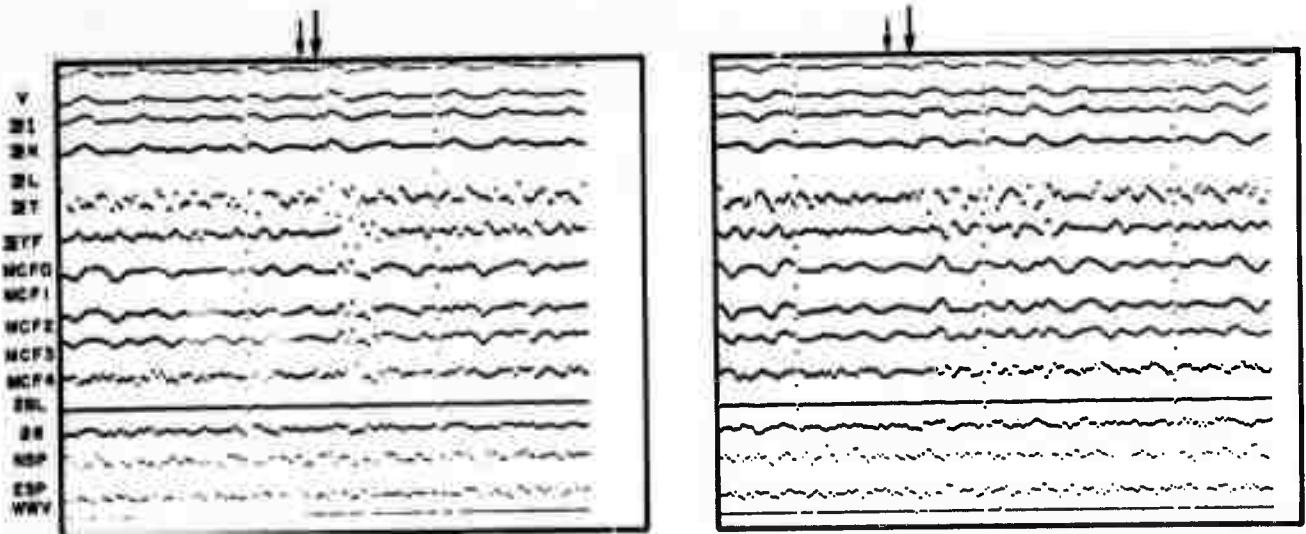
JULY 9, 1966

JULY 10, 1966

Figure 15. CPO Primary and Secondary Develocorder Records



PRIMARY



SECONDARY

JULY 10, 1966

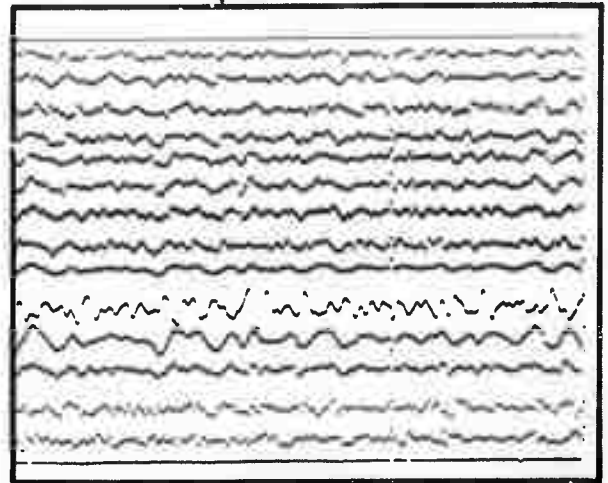
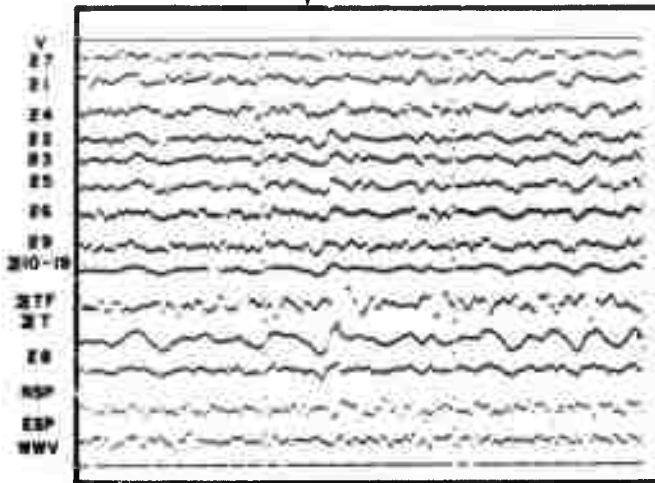
JULY 10, 1966

Figure 16. CPO Primary and Secondary Develocorder Records

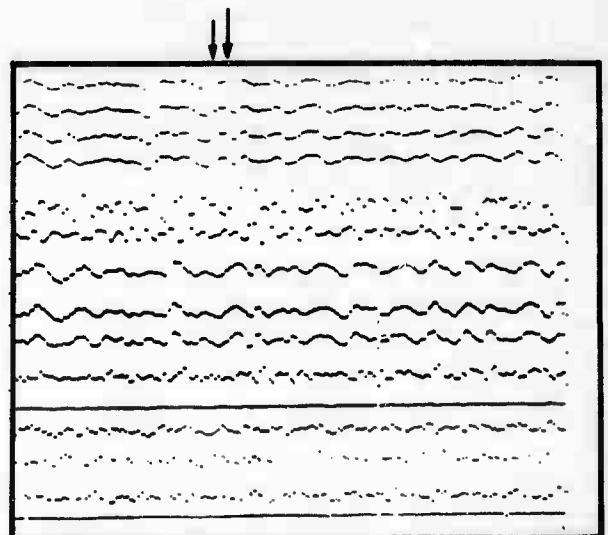
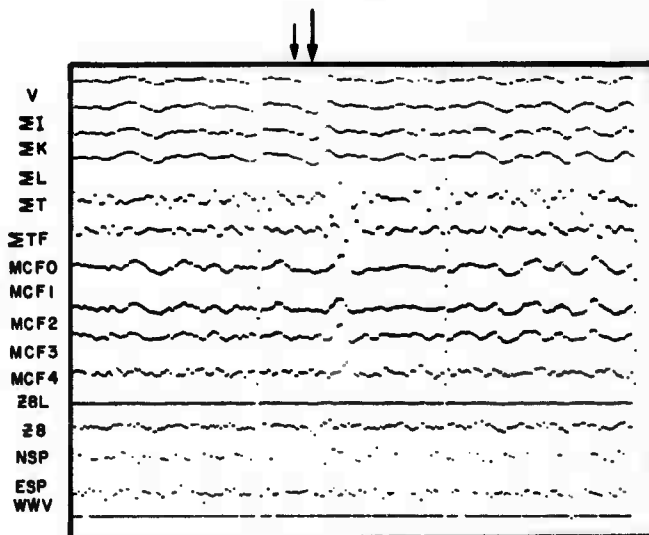


06 20 33.2

09 29 02.5



PRIMARY



SECONDARY

JULY 11, 1966

JULY 11, 1966

Figure 17. CPO Primary and Secondary Develocorder Records



Of particular interest are the events shown in Figures 8, 10 and 12 as follows:

- Figure 8 — 21:47:10.2

While this event is discernable on the summation traces, the first motions are much clearer on the MCF traces

- Figure 10 — 19:09:52.5

This event clearly shows the ability of the MCF traces to allow identification of a small signal masked by a larger one

- Figure 12 — 04:39:12.9

This record shows almost no motion on the sum traces, but presents good first motions on the MCF data



APPENDIX

EVENTS REPORTED AT CPO DURING JULY 1966



APPENDIX

EVENTS REPORTED AT CPO DURING JULY 1966

The purpose of this appendix is to present two detailed lists of the events reported during July, 1966 as discussed in Section III-D.

Table A-1 presents the events which were reported using only the primary data and the summation traces.

Table A-2 shows the events which were reported using the DMCF and other available data.



Table A-1

Number of Events Reported at CPO
Without DMCF Data - July, 1966

<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
July 1, 1966	0504106 0529418 0605173 0639156 0651570 0707000 0932342 0945589 1041054 1045359 1402325 1648544 1916237 2022288	July 5, 1966	0231044 0232239 0335549 0409575 0445107 0517462 0646049 0724321 0944464
July 3, 1966	0029215 0143433 0405131 0506456 0601509 0645487 1059286 1532110 1611373 1713532 2049022	July 6, 1966	0436200 0516536 0741248 1046410 1747471 1947455
July 4, 1966	0017155 0103107 0147100 0306298 0325028 0358490 1051087 1209110 1224075 1323399 1402526 1413400 1844192 1901045 2005122 2017454 2112449 2358318	July 7, 1966	0016361 0457467 1002525 1308004 2335444
		July 8, 1966	0116505 0157082 0320149 0357376 0537427 0759491 0832525 0932525 0955059 1741033 1827246
		July 9, 1966	0033092 0441187 0832521 0932525 0950121 1608520 2327230
		July 10, 1966	0310430 0706210



<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
	0749032	July 14, 1966	0100533
	0832525		0103558
	0917239		0159408
	0932525		0220582
	1030283		0436533
	1631292		0832525
	1924282		0902526
July 11, 1966	0002240		0926110
	0121082		0932525
	0129163		1010278
	0254300		1226486
	0520428		1510361
	0550218		1646115
	0611152		1752100
	0734217		1803474
	0832525		1819535
	0910591		1922381
	0932525		2009012
	1124052		2019122
	1546565		2333083
	2129225	July 15, 1966	0233487
	2344016		0425334
July 12, 1966	0243400		0432040
	0308452		0802179
	0326380		0805490
	0450100		0809005
	0811248		0811246
	0832525		0832525
	0932525		0932525
	1905117		0950230
July 13, 1966	0014356		1052080
	0228118		1054351
	0250100	July 16, 1966	0002181
	0826001		0053395
	0832523		0056523
	0839564		0739023
	0859300		1826295
	0932525	July 17, 1966	0019464
	1041397		0112426
	1043150		0541435
	1057035		0854578
	1217291		0902098
	1459332		1046191
	2050259		1049492



<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
	1429364		0540021
	2043589		0605380
	2049275		0608589
	2130101		0832525
	2336320		0932525
July 18, 1966	0452509		1232140
	0615053		1428106
	0859509		1442059
	0902524		1450037
	1002525		1536307
	1053522		1725461
	1114495		1942190
	2227116		2033230
	2246472		2203332
July 20, 1966	0230179	July 24, 1966	0320146
	0418150		0444213
	0557355		0453167
	0808269		0534070
	0832524		0553553
	0905170		0617005
	0907598		0759586
	0932524		0832525
	0944128		0854085
	0947205		0932525
	1028150		1333077
	1103568		1351027
	1332200		1543344
	1339580		1641300
	1401100		1856032
	1437332	July 25, 1966	0047410
	2010197		0541415
July 22, 1966	0353510		0832525
	0832525		0853109
	0844514		0928391
	0855090		0932515
	0932525		1019520
	1004180		1122102
	1027362		1150096
	1109580		2109305
	1955274	July 26, 1966	0004495
July 23, 1966	0156187		0202473
	0326400		0314287
	0348119		0359439
	0419516		0507589
			0525558
			0558554



<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
	0634347		0808443
	0932525		1923416
	1112557		2227316
	1300345		2323031
	1623167		
	1841445		
	2116586		
July 27, 1966	2202008		
	0150290		
	0307440		
	0459114		
	0520541		
	0817228		
	0832525		
	0932525		
	2320218		
July 28, 1966	0456447		
	0551311		
	0748304		
	0832523		
	0932525		
	1100193		
	1106599		
	1110225		
	2048305		
	2243000		
July 29, 1966	0042177		
	0327403		
	0438405		
	0720565		
	0922410		
	1004380		
	1610157		
	1635020		
July 30, 1966	1729510		
	1758200		
	2042059		
	2205240		
July 31, 1966	0138206		
	0308529		
	0624175		
	0757384		
	0809430		
	1757239		



Table A-2
Number of Events Reported at CPO
with DMCF Data - July, 1966

<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
July 1, 1966	0501497 0504102 0529417 0605162 0639155 0651563 0707058 0945587 0945587 1041044 1045353 1402325 1648527 1916236 2022287 2328046	July 4, 1966	1756110 1851224 2049013 2147102 0017154 0103097 0109053 0147094 0306297 0325022 0358490 0557119 0740050 0743283 0751289 0831423 1026349 1051561 1209114 1224075 1323397 1402524 1413370 1844191 1856257 1900589 1909525 1929480 2005181 2017454 2112447 2224553 2358310
July 2, 1966	0022051 0903026 0943184 1924338 1943057 2132118 2306499 2309385	July 5, 1966	0133327 0231046 0232075 0335538 0339541
July 3, 1966	0029205 0143450 0405130 0427215 0458207 0506348 0601505 0645487 0844187 1059283 1330556 1532138 1611364 1713521		



<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
	0409574	July 9, 1966	0033089
	0439129		0127182
	0445102		0141457
	0517461		0315240
	0552310		0419366
	0645578		0441181
	0724351		0832512
	0910530		0932512
	0944162		0950120
	1044066		1249369
	1102018		1608520
	1618349		2337233
	1832492		2353189
July 6, 1966	0350036	July 10, 1966	0249464
	0404214		0310424
	0436193		0558584
	0516535		0605441
	0628321		0702510
	0741246		0706207
	1046407		0749029
	1741071		0805439
	1931454		0832512
			0917537
			0932512
July 7, 1966	0016361		1019096
	0435369		1030145
	0457537		1139484
	1002516		1157431
	1308003		1217165
	2335443		1414203
			1627537
			1802089
July 8, 1966	0034220		1924278
	0116507		2007485
	0157075		2223252
	0221542		
	0320142	July 11, 1966	0002140
	0357375		0017126
	0537427		0121076
	0738221		0129162
	0739089		0254153
	0832513		0318316
	0932515		0401532
	1037390		0519422
	1123353		0550216
	1327195		0611143
	1741034		0620332
	1827221		0734215
	2011559		



<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
	092514		113500
	0911072		1217291
	0929025		1459337
	0932513		1728022
	1124050		1805579
	1253075		2046157
	1546563		2050258
	2129249		2340016
	2316122		
	2337475		
July 12, 1966	0008265	July 14, 1966	0100528
	0059110		0103543
	0113407		0159408
	0202242		0220581
	0203006		0436529
	0243396		0632152
	0253380		0741340
	0308478		0751477
	0326445		0832514
	0423563		0902515
	0450069		0932514
	0615465		1010273
	0618322		1226482
	0811247		1510360
	0832512		1646115
	0932510		1752107
	1032385		1803452
	1507570		1818112
	1905419		1819521
			1922370
July 13, 1966	0014351		2009010
	0016423		2012119
	0228112		2333084
	0235258		2352130
	0250092		
	0307293	July 15, 1966	0001047
	0538550		0233475
	0704433		0425330
	0826003		0432049
	0832514		0541499
	0819550		0802176
	0819277		0805491
	0927358		0833513
	0932512		0932513
	0957096		0950220
	1041392		1015192
	1043148		1035124
	1057066		1043421
			1052076



<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
	1054346		1053522
	2060362		1114491
	2345292		1758360
July 16, 1966	0002179		2104079
	0012152		2227113
	0053373	July 19, 1966	2246472
	0056521		0042217
	0133031		0116012
	0328120		0152101
	0421575		0112303
	0630590		0552070
	0739021		0548551
	1201150		0735227
	1233417		0032514
	1356529		0932514
	1403535		1016006
	1739438		1210384
	1757265		1930473
	1825368		1948137
	1826295		2125323
	1857192		2128559
	1914109		
	2015090	July 20, 1966	0230176
	2352343		0418136
July 17, 1966	0019456		0532420
	0112420		0557354
	0243295		0657326
	0452011		0806271
	0541432		0832512
	0854572		0901537
	0902082		0905167
	1046177		0907589
	1049487		0932512
	1312155		0944121
	1429358		0947205
	2043584		1028149
	2049273		1056446
	2107215		1103563
	2130059		1127582
	2336309		1332189
July 18, 1966	0147193		1339578
	0213591		1401093
	0452508		1437328
	0615049		1752216
	0859406		1821258
	0902512		2010197
	1002514		2145284
			2332275



Date
July 21, 1966

Arrival Times

0105333
0211486
0352150
0358329
0411169
0415019
0422111
0435584
0523568
0540163
0603026
0646317
0651544
0729015
0741570
0832512
0912292
0925045
0932512
0941467
1013018
1058290
1126417
1209419
1330231
1334199
1358599
1605007
1843110
1859058
2220595

July 22, 1966

0353503
0507595
0552514
0738003
0832514
0844506
0855009
0902513
1004166
1027362
1109580
1502587
1800195
1903354
1955271
2018043
2315047
2339206

Date
July 23, 1966

Arrival Times

0143269
0154287
0255474
0326390
0348110
0405451
0419516
0441534
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<u>Date</u>	<u>Arrival Times</u>	<u>Date</u>	<u>Arrival Times</u>
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